

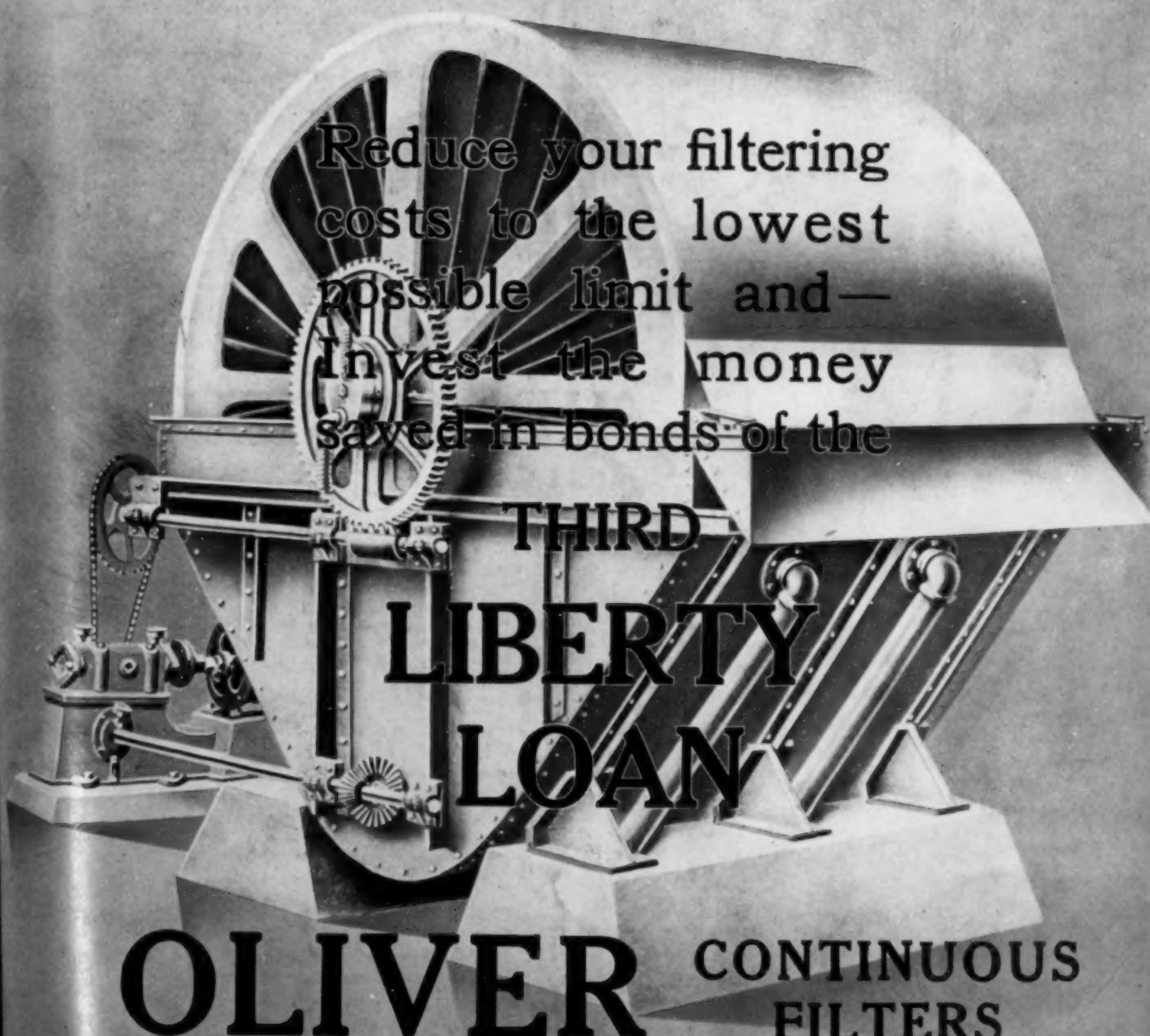
Metallurgical & Chemical Engineering

New York, April 1, 1918

McGraw-Hill Company, Inc.

Vol. XVIII, No. 7

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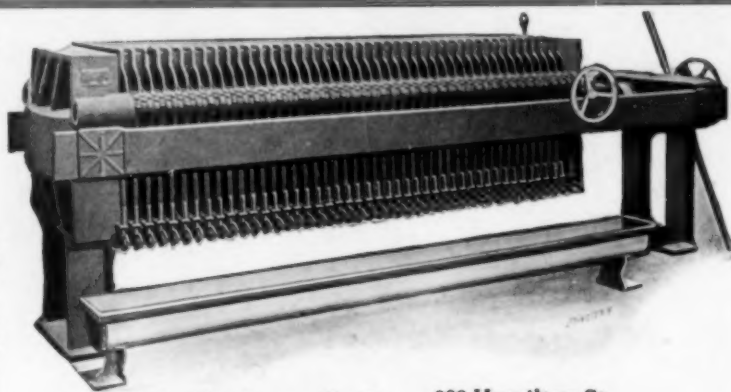
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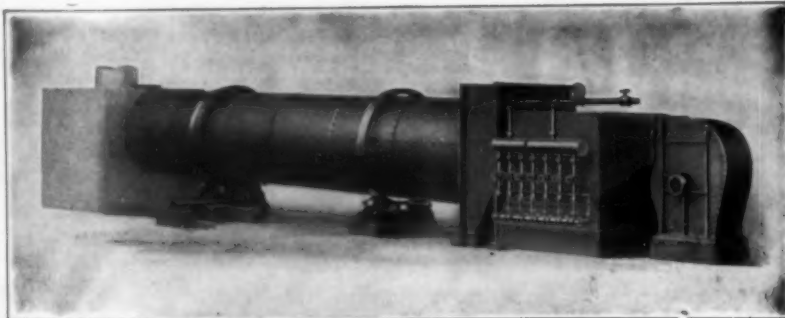
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A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

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Unwavering Purpose

THERE comes a time in every fight for principle when the critical factor for victory is steadfastness of purpose, a clear vision of the goal, and a determination to win. This is particularly true if the enemy for the time being is apparently victorious and defeat stares us in the face. Then if ever is the time to tighten the grip and determine to fight to the finish.

Let us have no delusions about the war—our war. Germany is winning it to-day, has been winning it for some time past; not always by force of arms, but often by the poison of subtle propaganda. We have only begun to play our part, and the peak of our participation cannot come for another year or more. In the meantime many demands are going to be made on us, one of which is to translate patriotism into dollars and make a success of our Liberty Loans. There must be no wavering, no question of success. If the United States is to come out of this war more than an economic vassal of her enemy; if the chemical and metallurgical industries of this country are to endure; if we are to hold what we have gained and protect what we have already given, then there is naught for us to do but respond to every call. We haven't yet begun to sacrifice in this country; we have yet to earn that glory.

Our supplement to this issue typifies the spirit of unity we would engender in our people—a spirit that will say with Lincoln, "We accepted this war for a just and worthy object and the war will end when that object is attained. Under God, I hope it will not end until that time."

The Need for Chemical Statistics

FOR some time past the conviction has been growing that a beginning should be made toward the gathering and publication of vital statistics in the chemical industry. As nearly as we can ascertain, there is a feeling that our chemical industry has become established on a fairly firm foundation; that the war has lasted long enough to insure a degree of permanence that would have been impossible if Germany had achieved her ends by a swift stroke; and finally that the longer the war lasts the more certain will be our chemical independence. If these things are true—and we believe they are—we should have better facilities for exact knowledge of the industry. Specifically we should have organized sources of information as to imports, exports, raw materials, finished products, production and consumption. These data are a necessary guide to logical and sound development in the industry.

We believe that the work should be undertaken by the cooperation of established government agencies. Since many of the raw materials of chemical manufac-

ture are of a mineral nature, and inasmuch as the United States Geological Survey has already extended the scope of "Mineral Resources of the United States" to include potash, sulphuric acid, cement, phosphate, etc., we suggest that a beginning be made here and that the work be elaborated. It would be of incalculable value at this stage of our growth to have chemical statistics and data comparable to those which the mineral industry enjoys. If the Survey is not the agency for this work, the Bureau of Mines may be.

Happily a beginning has been made toward a knowledge of our chemical imports. Dr. E. R. Pickerell, chemist in charge of the United States Appraiser's Laboratory, New York, is gathering data for the year prior to the war, June 1, 1913 to June 30, 1914. The completed work will show what competition we will have to meet and what essentials we will have to produce. This should be continued as an annual report and extended to cover exports as well. Such data combined with the domestic statistics previously suggested will fortify the chemical industry immeasurably. In established government agencies like the Bureau of Foreign and Domestic Commerce, the Geological Survey and the Bureau of Mines we have the machinery to make a quick start toward exact knowledge of the chemical industry.

Electric Furnaces for Zinc Melting

WE HAVE always held and often expressed a faith in the rôle of the electric furnace in the metallurgy of zinc. Proponents of the retort furnace are still prone to lift their eyebrows skeptically whenever electric-furnace spelter is mentioned; but the most partisan of these adherents must have seen a great light in the sudden perfecting of as difficult and elusive a process—zinc from electrolytic tanks. The economic reduction of zinc oxide by electrothermal methods is as well established as the reduction of zinc sulphate by electrochemical, and he would be stubbornly foolish to maintain that the remaining problem of economic condensation is unsolvable.

However, the electric furnace will undoubtedly come into its own as a melter of zinc metal and alloys before its common adoption for reduction purposes. Electric brass-melting is in its infancy, but even so the installation of the first furnace has been generally followed by additional units. Naturally some failures have resulted in trying to adapt the furnace to its duty: as an extreme instance, an arc furnace for melting zinc would be as useful as a bull jig for slime concentration. Brief consideration of the problem of melting a fusible, volatile and combustible metal seems to indicate the need of a moderate furnace temperature, preferably with heat applied below the bath and a closed laboratory containing an atmosphere controlled as to composition and pressure. These ideals involve structural complications which may be impossible to attain fully in large-capacity furnaces, even though it may now be possible to build and operate small induction furnaces under such conditions. Large furnaces reverberating heat down into the bath from resistors placed alongside fulfill most of the requirements, however, and are operating quite satisfactorily to-day.

The days of the older pot-practice of forming alloys

in melting holes seem to be numbered by the growth of foundries producing large tonnages of uniform metal. How long would an electrolytic copper or zinc refinery, for instance, tolerate the melting of a hundred tons of cathodes daily in pot-charges of 200 pounds? The rising cost and decreasing quality of the crucibles, the excessively low thermal efficiency of the fuel used, the huge furnace building and quantities of skilled labor required, alike exclude this practice from a modern metallurgical plant. This whole question has been fought over in the similar problem of the manufacture of tool steel—crucible steel. In both instances the sole justification of crucible practice has been "quality," and the electric furnace has beaten the crucible at its own game!

Tariff Philosophy

NOBODY who is informed can claim that we have never had a wise, just and equitable tariff bill framed, as a whole, into law. We lacked the tools, the necessary instruments, to make it. We had only congressional committees composed mainly of lawyers; and lawyers, while of necessity a part of the order of life in civilization, are not the creators of civilization. Lawyers are finishers rather than producers.

Now we have an able Tariff Commission to collect and arrange information, but not to legislate, and the play of psychology in legislation is something we must consider. In other words, we must consider beforehand how Congress will feel when it has a tariff act to vote upon. Under our present laws, in regard to certain industries, there are loopholes through which foreign manufacturers can creep with their products and disorganize American industry by sheer astuteness, without even employing deceit. They can do this within the law. An easy way to avoid this danger is to stop up the loopholes by raising the tariff imposts. The real way is to go over the laws in good faith and with honest and frank examination of their provisions in detail.

The trouble with the mere process of just boosting the duties is that it raises the cost of things, and when the cost of things goes up public opinion comes down upon it. When public opinion is unfavorable to an increase in tariff rates Congress will not increase them. It makes no difference what the facts are, or where wisdom lies; Congress reflects public opinion, and public opinion is a contagious emotion. Now, emotion is not thoughtful.

It stands to reason, then, that if associations of manufacturers confine themselves to "helping" the Tariff Commission by pointing out only where higher duties are needed, the voice of public opinion, speaking of these persistent efforts, will be to the effect that manufacturers are the same yesterday, to-day, and forever, and that, like cherubim and seraphim, they continually do cry the song that was indicated by the chorus of manufacturers in the Chemical Grand Opera:

"Protection, Protection, we surely need some more;

We need it now and all the time; we've needed it before.

We chant our old Protection Hymn—it shows the easy way

To bring about Prosperity and let us Make some Hay."

And when public opinion concludes that manufacturers are presenting their claims with minds single to their own interests, and without consideration of the public welfare, like a lawyer trying a case at court who leaves all unfavorable evidence to be developed by opposing counsel, public opinion will close its mind to their appeal, and manufacturers will have no standing at its court, which is the Congress.

The Tariff Committees of Manufacturers' Associations are likely to fail in their efforts if they conceive their duties in the restricted sense of a lawyer at court. They must conceive their duties rather in the manner of a judge advocate at a court martial, looking for the truth and the general welfare rather than to how much they can get. They should not only give the impression of being fair, but be fair. If they appear before the Tariff Commission they should go with all the evidence instead of only that which favors them, and for every advance they ask they should offer a reduction if possible. Every product that can be made here with reasonable profit in world competition, without duty and without reduction in wages, should be made duty-free. It is the business of the Tariff Commission to discover these things and tell them to Congress; so why should not manufacturers tell them to the commission and aid in the reduction of unnecessary duties so that the tariff wall does not grow up too high? This it has often done in the past, only to fall down again like the walls of Jericho at the blast of public opinion, to the confusion and misery of all.

Public opinion in this country is neither docile nor obedient, as it is in Germany. It is subject also to the sinister influence of yellow newspapers which live by loud noise, and the loudest noise can be made in protest. Constructive thought is not noisy, and therefore it is unavailable to the yellow press. On the other hand, public opinion has a mind to fairness, and if manufacturers show themselves fair and in favor of a fair tariff they will stand a better chance than ever before of getting a fair deal. No one should ask for pork, which in politics means something for nothing, or wage without service. The ear of the public mind is sensitive to the cry for pork, and the response is usually violent—violent and destructive.

A Poor Pig-Iron Showing

THE only favorable reflection that can be made upon the record of pig-iron production in 1917 is that at the end of the year the Government took over the railroads with the intention of getting better service out of them, chiefly by doing things which the Government had not permitted the railroads themselves to do. The year's pig-iron production, as now officially reported, was 38,647,397 gross tons, against 39,434,797 tons in 1916, the record year. The decrease of 2.0 per cent is to be considered in connection with the fact that new blast-furnaces, averaging at least 150,000 tons' annual capacity per stack, were blown in as follows: In 1916, one each in May, June, November and December; in 1917, one in the first quarter, five in the second quarter, eight in the third quarter. The eighteen stacks have a capacity of about 3,000,000 tons a year, and considering the times at which they were blown in it is evident they contributed scarcely anything to the 1916 output, whereas the old furnaces and

new furnaces combined should have been able to make between 41,000,000 and 41,500,000 tons in 1917.

The deficiency of nearly 3,000,000 tons in the 1917 production was due entirely to an insufficient supply of coke. That arose almost wholly from the railroads being unable to haul coal to by-product coke ovens and coke from beehive ovens to furnaces. The shortage in the movement of Connellsville coke, as a matter of fact, began late in November, 1916, and at no time thereafter was there a full movement. The statistics of Connellsville coke shipments, compiled by the *Courier*, show 21,654,502 net tons moved in 1916 and 17,806,181 tons moved in 1917, a decrease of 3,850,000 net tons, which at 2300 pounds of coke per ton of pig-iron would account for 3,300,000 tons of pig-iron. As a matter of fact, the decrease in pig-iron produced from Connellsville coke was greater than that, because with irregular operation of ovens the quality of coke deteriorated, and with irregular operation of furnaces, including frequent bankings, the coke requirements per ton of pig iron increased. Partial relief was afforded by the output of by-product coke increasing about 3,500,000 tons. The coke troubles did not end with 1917, for conditions were still worse in January and February of this year, and it is doubtful whether even now the rate of pig-iron production is up to the average of 1917. For the future it is a case of having hopes.

There were interesting changes in the distribution as to grades of the pig-iron produced in 1916 and 1917. Basic iron, which constituted about 45 per cent of the total make, decreased in output less than 0.1 per cent, while Bessemer decreased 4.9 per cent. The two grades of steel-making iron together decreased 2.3 per cent. Foundry and ferrosilicon decreased 4.1 per cent, while malleable increased no less than 10.2 per cent, although in 1917 it comprised only 2.3 per cent of the total pig-iron output. Ferromanganese output increased from 221,532 tons to 286,000 tons, or 29 per cent. Adding imports, the apparent supply was 312,460 tons in 1916 and 331,381 tons in 1917.

Although the production of Bessemer and basic pig iron decreased 2.3 per cent from 1916 to 1917 there appears to have been an increase in steel-ingot production, as partial returns indicate an ingot production of 42,200,000 tons in 1917, against 41,400,000 tons in 1916. There was hardly an increase in old material available, but more likely a decrease. Stocks of workscrap were probably cleaned up in 1917 in the effort to make as much steel as possible, while whatever stocks of pig iron existed at the beginning of the year were consumed, probably to the extent of more than a million tons.

The total output of basic iron in 1917 was 17,671,662 tons, and of this 15,056,787 tons was produced by consumers. The amount of iron delivered molten for consumption was 13,696,600 tons, and one may safely assume that practically all of this was produced by the producer-consumer class, so that of the basic iron they produced they used direct 90.97 per cent. The proportion of direct metal charged by the same works was much less, on account of the use of stocks.

While the total production of pig iron decreased 2.0 per cent in 1917, the production of merchant iron increased from 11,253,317 tons to 11,676,513 tons, or by 3.8 per cent, the merchant output in 1917 constituting 30 per cent of the total.



**The Buying Line
OVER HERE
Helps the Firing Line
OVER THERE**



Our April Business

Patriotic Messages from Representatives of the Chemical and Metallurgical Industries

BY WILLIAM H. NICHOLS

President American Chemical Society, Chairman of the Board,
General Chemical Co.

Like the two loans which preceded it, the Third Liberty Loan affords an opportunity for the American people to show the depth of their patriotism by acts rather than words. This, of course, is true of the chemical industry, as it is of all others, and the opportunity thus afforded to co-operate with our Government should be looked upon as a privilege. This applies as much to the humblest workman as it does to those holding the highest position and, judging from the previous campaigns that have come under my observation, they thoroughly appreciate this. In several of the works of this company every single employee subscribed to the second loan, and in all of the works a very large proportion took bonds. I expect that similar results will be reached in the third loan.

The chemical industry has not been found lacking in any respect since our entry into the war and has consistently done its duty. It realizes that much depends upon it, and will make every effort to do its part until the successful termination.

New York City.

BY PAUL J. KRUESI.

President Southern Ferro Alloys Co.

The next big victory of the European war must be won here in the United States. Our success in this loan will be magically reflected in the valorous deeds of our brothers and sons in breaking the deadlock on the western front.

Our April business, therefore, is to make an overwhelming success of the Third War Loan—happily named by Mr. McAdoo the Liberty Loan. Of it we must buy and buy, not what each can comfortably digest, but all that our credit will permit when strained as credit was never strained before. Then when we would preen ourselves on our virtuous patriotism we must take a hand in the selling, making the other fellow do what we have first done ourselves.

Never should we forget or allow him to forget how trivial is the curtailment of our ordinary luxuries and comforts as compared with the privations of war imposed on our gallant allies and our own sons at the front.

In no field should more be expected than in those of electrochemistry and metallurgy, than which none has been more stimulated by war and than which none has more at stake in defeating German world-dominion.

Nations like men are accepted at their own estimates until they fail in their own pretensions. From now on France and England expect the morale of their armies to be sustained by ours. Can anyone picture the demoralization and humiliation were we to fail in a bond issue? The end is measurably near whenever we fail, for our armies and our allies will only be beaten when we are.

Away then with so much talk of peace, for the only kind of peace now would be of the "Made in Germany" brand. Away with the faint-hearted who will argue that the "saturation point" in bond sales has been reached! Away to the internment camps with those worst of slackers who claim they are "too busy" to help sell bonds for the liberty they enjoy!

We, who have been the four-year beneficiaries of all their expenditure of blood and treasure, shall we then falter when our brave allies call "Come, and come with all your speed and might?"

Chattanooga, Tenn.

BY G. W. THOMPSON

President American Institute of Chemical Engineers

I am indeed glad to join in urging those in the chemical industries to do everything in their power to make this, the Third Liberty Loan, a great success. We must subscribe ourselves—we must urge others to subscribe. If we value the really good things in life, if we have affection for our friends and treasure our family ties, if we hold to any principles on which we believe civilization and progress

to rest, this is the time to show it. I believe everyone should step forward and seal his devotion to the cause of liberty now. It is the only way.

Brooklyn, N. Y.

BY J. V. N. DORR,

President The Dorr Co.

The technical man whose work helps the production of essentials feels himself a slacker when he thinks of those going over to pay with their lives for his freedom. His only salvation is to push his work with every ounce of energy and buy Liberty Bonds with every cent he can save.

This is an engineering war and, if there ever was one, it is a "rush job." The chief engineer must not be hampered by lack of funds, and it is up to us not on the firing line to make up for the lack of preparation which we regret by giving every ounce of our energy and every dollar we can save.

America's reply to the Hun offensive must be such an over subscription to this Liberty bond issue that Germany will realize the nation to the last man is behind the war and prepared to win peace only by victory.

It is up to the technical men who realized our danger when the politicians slept to do more than their share in this loan and then start to save for the next.

New York City.

BY COLIN G. FINK

President American Electrochemical Society

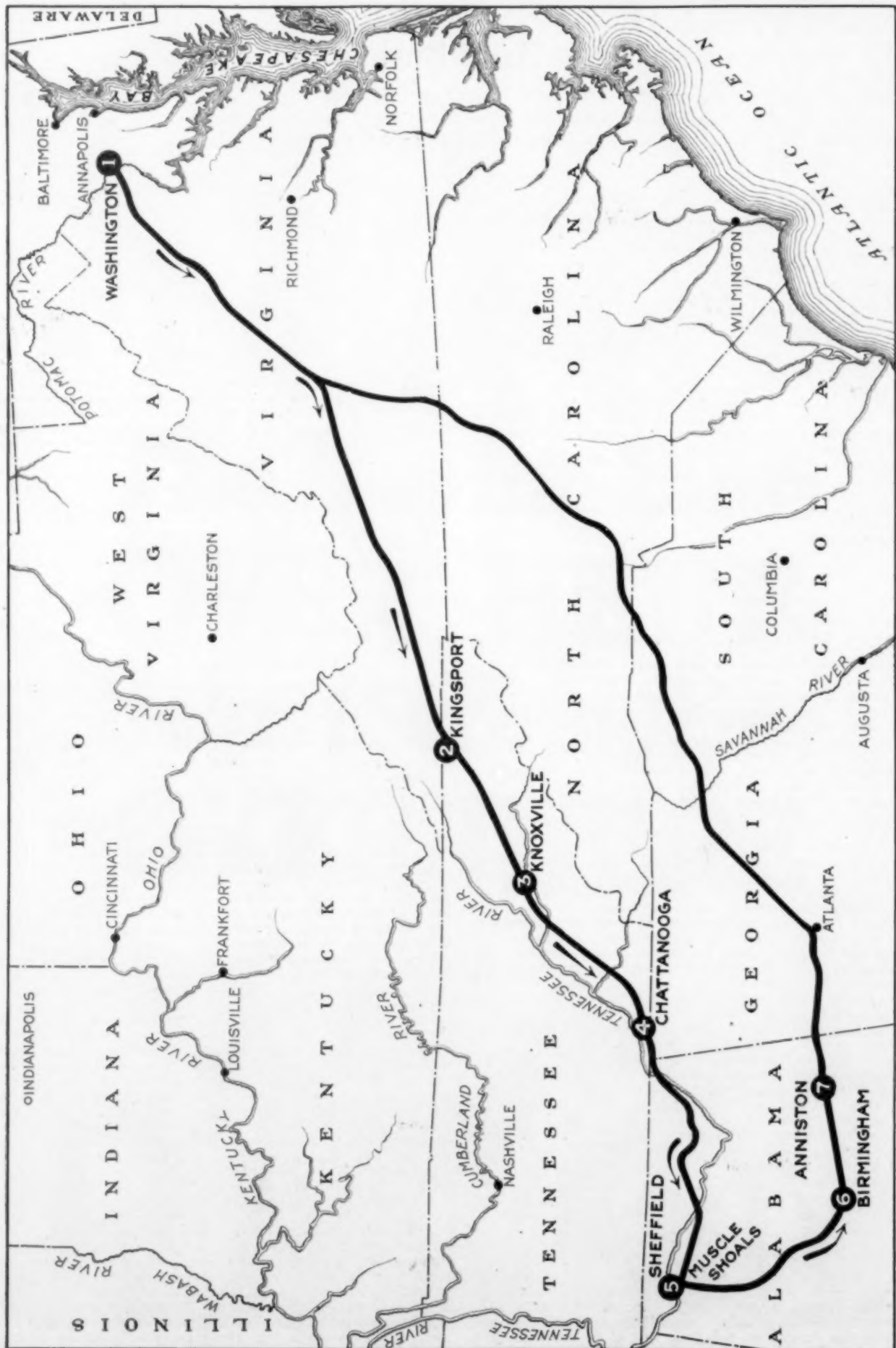
In 1848, when Europe was revolting against monarchies, young Louis Pasteur, while passing through the Place du Panthéon, noticed a little altar with the inscription "Autel de la Patrie." The words kindled his patriotic spirit, and he offered at once his entire humble fortune of 150 francs. The same spirit that pervaded the scientific researches of Pasteur, resulting in so many world successes—this same spirit in its patriotic guise led him to enroll in the National Guards and offer his meager savings besides.

In our appeal to-day to electrochemists and metallurgists to contribute and assist in making the Third Liberty Loan a most emphatic and unparalleled success, we feel thoroughly confident that we need not impress upon them the dire consequences of a possible failure of this loan campaign. A scientific mind will easily appreciate the results. Lack of financial support means defeat. Unless we loan our money to the Government to-day we will have to forfeit it later to the German invader.

President Hibben of Princeton recently remarked to a large audience of engineers, "Germany is winning this war." Our American newspapers have been pursuing a policy of minimizing German successes, with the result that many of our people do not realize that Germany is winning this war. They look upon the task that we have undertaken rather lightly and feel as though the Government will easily handle the situation without any support from the individual. The fact is that our task is a very difficult one. Win we must, and win we shall, but it will require the utmost effort of every man. We must support the Government in every detail of its complex war program. In order to keep our soldiers and sailors well supplied with the very best in munitions and provisions our Government requires money, much money, and more money! Hundreds of ships must be built, thousands of shells and guns manufactured and millions of tons of wheat and meat transported across the Atlantic.

Put your shoulder to the wheel. If you cannot go to France and fight, do all you can to help those that are fighting for you. If you are not yet convinced that you must support the Government financially, don't stop until you are convinced. And if you are convinced, don't stop until you have convinced others. On April 4 it will be just one hundred years since the adoption of our flag by Congress. Let us make this anniversary one worthy of the high ideals our flag represents!

New York City.



ROUTE OF SOUTHERN TRIP, AMERICAN ELECTROCHEMICAL SOCIETY, APRIL 28-MAY 5.

Spring Meeting and Southern Trip of American Electrochemical Society

Tentative Program of Visit to Technical Centers of Tennessee and Alabama, Including Government Projects at Muscle Shoals

WITH the official approval of the Director General of Railroads, the final plans of the American Electrochemical Society for its spring meeting and Southern trip are rapidly nearing completion. For the benefit and information of those who have decided or may yet decide to join the party, we give a provisional program and outline of the trip.

ITINERARY

1. WASHINGTON, D. C., Sunday, April 28. The party will gather at this point and leave some time late in the afternoon over the route shown in the sketch map on the opposite page. Stops will be made at six points, spending one day or part of a day at each place. The general plan contemplates visits to industrial plants and hydroelectric power stations during the day, with technical sessions in the evenings. Returning, the party will reach Washington some time Sunday morning, May 5.

2. KINGSFORT, TENN., Monday, April 29. This community enjoys the distinction of having a complete cycle of chemical and electrochemical industries, inter-related and co-ordinated to an unusual degree.

It is planned to arrive in time for breakfast and spend the day visiting plants, stopping at noon for lunch at Rotherwood Farm. Following are the industries and points of interest: Federal Dyestuff & Chemical Company, electrolytic chlorine plant, Allen cells; Kingsport Brick Corporation; Clinchfield Portland Cement Corporation, Cottrell plant for potash recovery, and steam-electric power plant; Kingsport Extract Corporation, oak and chestnut tanning extracts used by the Kingsport Tanning Corporation; Kingsport Pulp Corporation, paper pulp from spent chips from extract mill; Kingsport Paper Corporation; two alcohol plants.

In the evening there will be a dinner at the Inn, followed by the annual business meeting, motion pictures, dancing, etc. A special exhibit of minerals of the region will be on display.

3. KNOXVILLE DISTRICT, TENN., Tuesday, April 30. A preliminary stop will be made at Mascot for breakfast and a visit to the zinc concentrating mill of the American Zinc, Lead & Smelting Company. The oil flotation process is in use here. Arriving at Knoxville, there may be a technical session until lunch time, after which the party will be taken to one of the dam sites of the Aluminum Company of America on the Little Tennessee River. This development is planned to yield 400,000 hp. and is typical of such power possibilities in the region. In the evening there will be a banquet at the Country Club and a lecture by Prof. Switzer of the University of Tennessee on the hydroelectric and industrial resources of the region. This lecture has been specially prepared in anticipation of the meeting.

4. CHATTANOOGA, TENN., Wednesday, May 1. At this point are the plants of the Kalbfleisch Chemical

Company, sulphuric acid and alum; the Chattanooga Gas & Coal Products Company, the Southern Ferro Alloys Company, ferrosilicon, and Wilson & Company, cotton seed oil. There are also a modern bleachery, textile mill and government munition plant. An afternoon boat trip is planned to Hale Bar, where the Tennessee Power Company has a dam and power plant developing 100,000 hp. A complimentary banquet will be served in the evening.

5. SHEFFIELD AND MUSCLE SHOALS, ALA., Thursday, May 2. This region is famous for its power possibilities and for the location of two plants for fixation of atmospheric nitrogen. The government is building and will operate a nitrate plant for the synthesis and oxidation of ammonia. The Air Nitrates Corporation is the agent of the Ordnance Department, U. S. A., for the manufacture of ammonium nitrate by the cyanamide process. Construction is well advanced on the nitrate plant and may be under way on the cyanamide plant. In addition to inspecting these plants as far as possible, the party will go by boat up through Muscle Shoals of the Tennessee River. President Wilson recently signed an order for the development of one of the power sites on the shoals to provide 600,000 hp.

6. BIRMINGHAM, ALA., Friday, May 3. This district is known for its iron and steel manufacture, to which has been added ferromanganese. The Tennessee Coal, Iron & Railroad Company at Bessemer makes ferromanganese in a blast furnace, and steel by the duplex process. At Ensley there is a by-product coke plant. Plans for this stop are yet to be completed.

7. ANNISTON, ALA., Saturday, May 4. A short stop of perhaps four hours is planned. At this point are the electric furnace plants of the Anniston Steel Company, making low-phosphorus pig iron and electric steel castings, and the Southern Manganese Corporation, making ferro-manganese and either ferro-chrome or silicon.

The following estimate of expense has been submitted by the railroads, based on carrying 100 persons. Figures include war tax. Transportation, \$41.96; upper berth, \$15; lower, \$19; stateroom or compartment for two, \$22 each; drawing room for three, \$25 each. Leaving Anniston on the return trip, meals will be served on diner at table d'hôte rate of \$1.25 per meal. Railroad equipment will comprise one baggage car and pullmans, and it is anticipated that one of the latter will be a combination compartment and observation car.

In making visits to plants it is understood that competitors will not accept the courtesy unless they reciprocate it.

Those expecting to take the trip should notify J. W. Richards, secretary, Lehigh University, South Bethlehem, Pa., making their reservations and sending remittances to him. Any who expect to take only part of the trip should communicate with C. A. Kline, Southern Railway, Washington, D. C.

Readers' Views and Comments

Engineers in Training

To the Editor of Metallurgical & Chemical Engineering

SIR:—I have read with interest Professor Hill's article in the issue of your journal for December 15. It is of especial interest because some three years ago we established a new course at the Massachusetts Institute of Technology, entitled Engineering Administration, and in June of last year we graduated our first class in this course, numbering thirty-seven men. We could have placed a far larger number than those who graduated. Military service has called two-thirds of them at once, and it is rapidly extending its claims to the remainder, but such experience as we have had shows that there is a very specific demand for men who are engineers and who had their attention called to the problems of business management and human relationships which enter into industrial affairs.

DAVIS R. DEWEY.

Cambridge, Mass.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR: The humanizing and broadening of technical and engineering training are certainly most desirable, but the method of doing this must be most carefully guarded and many of the efforts thus far made are, I think, open to criticism. They most certainly have not attained the desired result and instead of cultivating a desire on the part of engineering students for economic and literary studies have had rather the opposite effect. If, as is sometimes the case, the courses in economics, sociology, etc., are recognized as the "snap" courses, which, though required of engineering students, are taken simply to ease up the program, I question if any satisfactory results will be obtained.

I happen to know of one instance where a young man through sickness was able to attend classes in one such subject for only a month out of the entire semester, yet he was permitted to take the examination without tutoring or doing any work excepting, as he himself put it, cramming for one day before the examination, and passed it. Certainly if this can be done a student is wasting his time by attending lectures throughout an entire semester.

The gist of the subject seems to me is contained in Prof. Hill's conclusion 8, "Non-technical instruction for technical students must be as efficient as technical instruction. Teachers through their own training and experience must be able to relate the non-technical teaching to definitely discover conditions and needs of the technical world itself."

I seriously question the advisability of having engineering students take, for instance, a course in labor problems given by a recent graduate in economics, who has yet to make the real acquaintance of a laboring man, but if such a course can be given by some one, be he an engineer or economist, who has actually been up against the labor problem, such a course would be most valuable.

One solution of the problem is the humanizing of technical subjects by emphasizing the economic, politi-

cal, and sociological phases, for which there is ample opportunity in most technical courses. For instance, economic geology lends itself admirably to the discussion of many current economic problems cognate to, but not ordinarily included under the head of geology. Such a strictly engineering course as the utilization of fuels certainly offers scope for a discussion of such pertinent economic problems as the recent coal situation. While I think that practically all teachers of engineering agree in the opinion that a liberalizing of our courses is advisable, the best way in which to solve the difficulty is by no means a settled question and many of the experiments now being made are not only not producing the results aimed at, but are taking the time which might better be spent on more distinctly technical subjects.

H. H. STOEK.

Urbana, Ill.

* * *

To the Editor of Metallurgical & Chemical Engineering

Sir:—During recent years a good many people have urged the importance of including courses in business administration, economics, accountancy and other similar subjects in the engineering curriculums with a view to familiarizing undergraduate students with some of the business practices of the commercial world. I have much sympathy with the desire that we turn out graduates from the technical schools who are well prepared to engage in commercial work, and I assume that sooner or later the engineering colleges will give way to the pressure which is likely to be brought to bear upon them for a modification of their curriculums so that they will include an increasing number of non-technical subjects. Five or six years ago the College of Engineering of the University of Illinois completely revised its various curriculums with a view to including a certain number of non-technical electives, in the expectation that students would be given a greater breadth of knowledge and that they might better compete with men of so-called liberal training. If I were to ask the members of our faculty their views of the success of our efforts to "liberalize" our curriculums I am inclined to think that the general opinion would be that the plan has not worked out as we had hoped, largely, perhaps, because the students themselves have too little appreciation of the probable demands of the future to select their electives wisely.

The engineering colleges of the country have been organized to give instruction in the fundamentals of engineering, with some specialization in various technical subjects. On the whole, I think that they have done a pretty good job in the training of men for technical engineering positions. We will all agree, I believe, that the graduates of the engineering schools are not engineers and that the best we can do is to give them the foundation for an engineering career. We are continually endeavoring to bring into the curriculums new technical courses to prepare men in various specialties which have developed as a result of the constant progress that is being made in

engineering science. In addition, as has been indicated, pressure is being brought to bear to include the so-called business courses in the engineering curriculums. Personally, I doubt whether it is possible to make many changes of this sort in a four-year curriculum without some danger that the basic subjects may be given reduced importance. If such changes should be made we may ultimately turn out men who are inadequately prepared either for engineering or for business. Perhaps the final solution of the problem will lie in the extension of the time required for the completion of an engineering course to five or even to six years.

In spite of my doubts regarding the propriety of including much instruction in the principles of business in the four-year engineering curriculum I recognize that the engineer of the future must play a larger part in the social and economic life of the community. During the reconstruction period which will follow the war, the principal problems to be met will be those of a social and economic nature. In one way or another the engineer must play a part in this reconstruction work, and it will undoubtedly be to the advantage of the country if his understanding of these problems is such that his influence may be employed to secure the largest measure of public good.

C. R. RICHARDS.

Urbana, Ill.

Poison Gases in the War

AT the regular March meeting of the Chicago Section of the American Chemical Society, held at the City Club on Friday evening, March 15, 1918, Major S. J. M. AULD, chemical adviser of the British Military Mission, thrilled his audience for about two hours with a description of the part played by gas in modern warfare. He described the first gas attack made by the Germans early in the war and the gallant resistance of the heroic men who met it without even the most primitive means of defense. He proceeded to tell about the development of the gas offensive from the first gas-cloud attack with chlorine to the use of phosgene, various tear and sneeze-producing gases, poison gases, and finally the latest accomplishments with gas shells. The great magnitude with which some of these attacks were carried on may be impressed upon us by learning that hundreds of tons of liquid chlorine have been used in a single attack, and that in some cases the drums of chlorine were placed so closely together that there were three for each two yards along a front of considerable length. The effect of weather conditions, the direction and velocity of the wind, the factor of safety, and many other details were explained.

In recent attacks with gas shells, as many as 35,000 to 50,000 shells have been dropped on a limited acreage in two or three hours. Some of the gas shells contained, in addition to the bursting charge of high explosive, bottles containing liquid, and in some cases even solid chemicals, which would be so completely atomized by the bursting of the shell that they would have the same effects as shells charged with liquefied gases. It was stated that a case was on record in which a shell which failed to explode was examined and found to contain bottles with the original Kahlbaum labels still intact.

Passing to the defensive, the speaker described the

development of the gas mask from a simple cloth bandage soaked in various chemicals to the elaborate mask which is now in universal use. As fast as the enemy introduced new devices for gas offense a suitable defense was provided to overcome it. The experience was bitter and costly, but at the present time the idea is prevalent that the worst is over, and that the defense is, in general, developed to a greater degree of efficiency than the offense.

It was very gratifying to hear him say that the mask produced by the Americans, and now in general use at the front, was considered superior to any of the others. Not only are the men provided with masks, but even the horses, mules and carrier pigeons are provided for. In the case of the horses and mules, as these animals breathe through the nose, a mask made of cloth soaked in chemicals is drawn over the nostrils. In the case of the pigeons, however, each bird is not provided with a separate mask. The cages in which they are confined are covered with preparations which prevent any of the objectionable gases reaching the interior.

In the composition of gas masks designed to neutralize the effects of chlorine and phosgene, the chemicals most used are sodium thiosulphate, sodium phenate, activated charcoal, and hexamethylene-tetramine.

Montreal Meeting of Canadian Mining Institute

THE twentieth annual meeting of the Canadian Mining Institute was held at the Windsor Hotel in Montreal, March 6 to 8. The meeting was opened on Wednesday morning, March 6, by Arthur A. Cole, president of the Institute. About 125 to 150 members were present, including several from the United States.

The report of the Council and the financial statement for 1917 were read and adopted.

The presidential address was then delivered by Mr. Cole. He showed how Canada had passed from a borrowing to a self-supporting nation since the war started. He said that one-ninth of the wage earners in Canada in 1915 were employed in the mining and dependent industries and 37.9 per cent of the tonnage supplied to the railways was the product of mines. He mentioned the large number of electric furnaces used in war work for the production of shell steel from turnings, and also the new industries of copper and zinc refining and magnesium production. He thought it highly desirable to keep the gold mines producing in order to maintain a gold reserve. He said one of the main deficiencies in natural resources was the lack of fuel in Central Canada. This could be partly relieved by a greater use of water power. In regard to a proposition put forth that all engineers should combine in a single society, he did not think this advisable owing to the different branches being so specialized, and during times of stress co-operation is easily secured between the executives of the different engineering societies.

A proposal by Dr. A. Stansfield to change the name of the society to the Canadian Mining and Metallurgical Institute was postponed for a year pending the formation of an iron and steel section.

Mr. D. B. Dowling of Ottawa was elected president and Messrs. J. A. Dresser, H. E. T. Haultain and A. E. Whiteside were elected vice-presidents.

Councillors were elected by acclamation as follows:

Quebec—Alfred Stansfield, Montreal.

Ontario—N. R. Fisher, Haileybury, Ont.

R. E. Hore, Toronto, Ont.

E. P. Mathewson, Toronto, Ont.

S. B. Wright, Deloro.

Alberta—Jules Charbonnier, Blairmore.

W. P. Williams, Bellevue.

British Columbia—R. H. Stewart, Vancouver.

George Wilkinson, Victoria.

W. R. Wilson, Fernie.

At the luncheon on Wednesday President Cole announced that a resolution had been unanimously passed by the Council to commemorate the twentieth annual meeting of the Institute by conferring life membership on their first president, Mr. John E. Hardman of Montreal, and Mr. J. Stevenson Brown of Montreal, who was for many years their treasurer.

The report of the Council showed that there had been a large increase in membership during the year. There were 125 members on active service, and eleven members had been killed in action. The total membership was 1118, as against 1066 in 1916.

A smoker was held on Thursday evening, at which the principal event was a paper on the Quebec Bridge, illustrated by lantern slides by Col. C. N. Monsarrat. He described the construction of the bridge completely from the work on the material in the shops to the final opening of the bridge for regular traffic.

The annual dinner was held Friday evening, at which Hon. Martin Burrell was the chief speaker. Mr. Burrell is the Minister of Mines in the new Federal Government.

A long list of papers was read in the three days, including general subjects, coal and fuel, flotation, iron and steel, ferro-alloys, mining, geology, etc.

Among those present at the meetings from the United States were Bradley Stoughton, secretary American Institute of Mining Engineers, New York; Eli T. Conner, Scranton, Pa.; C. Seymour Newcomb, New York, and H. M. Roberts, Minneapolis, Minn.

Toluol from Sulphite Wood-Pulp

IN our last issue we published a note on the possibility of augmenting our supply of toluol by treating the so-called spruce turpentine obtained from sulphite wood-pulp. This material is more properly known as sulphite turpentine or cymene. Its recovery has been made the subject of study by a special committee on toluol of the Technical Association of the Paper & Pulp Industry, and an official report has just been made by Henry E. Fletcher, chairman of the committee, to Captain H. C. Porter of the Ordnance Department recommending the adoption of a method developed by the Hammermill Paper Company. The report, which has reference to the accompanying diagram of the process, is as follows:

The committee has taken up this question by correspondence with various mill operators and chemists, and has come to the conclusion that the best system in vogue at present is the one that has been adopted by the Hammermill Paper Company of Erie, Pa., which has very generously offered the use of this method to any mill. The method is as follows:

Separating the relief gases and liquor, sending the relief gases through the gas cooler to a second separator *B*, shown on the accompanying sketch, this separator taking out the cymene plus a certain quantity of other condensates. You will note the dimensions of this separator for both the intake and discharge are about 6 in. in diameter and the separator itself about 15 in. in diameter and 5 ft. deep. There is a lead baffle-plate placed in the middle of the separator reaching to within a foot of the bottom. In the bottom of the separator is an outlet of about 2 in. diameter, which conducts to a separating tank the cymene, together with an aqueous SO_2 solution. This tank should be equipped with gage glass and indicator cocks. It may be noted here that the gage glass shown is subject to freezing and it would be more advisable to have a stove mortised and a section of from $\frac{1}{4}$ to $\frac{1}{2}$ inch plate glass inserted from 2 to 3 in. wide and 4 ft. long, answering as a window to the tank itself. From here we draw the aqueous solution of SO_2 from the bottom of the tank back to the acid storage tanks, and the cymene to tanks for the purpose of collecting the same. The more frequently this operation is repeated the better the resulting production will be.

The adoption of the method and the largest possible production of toluol, regardless of cost or profit, is urged on all pulp makers as a patriotic duty.

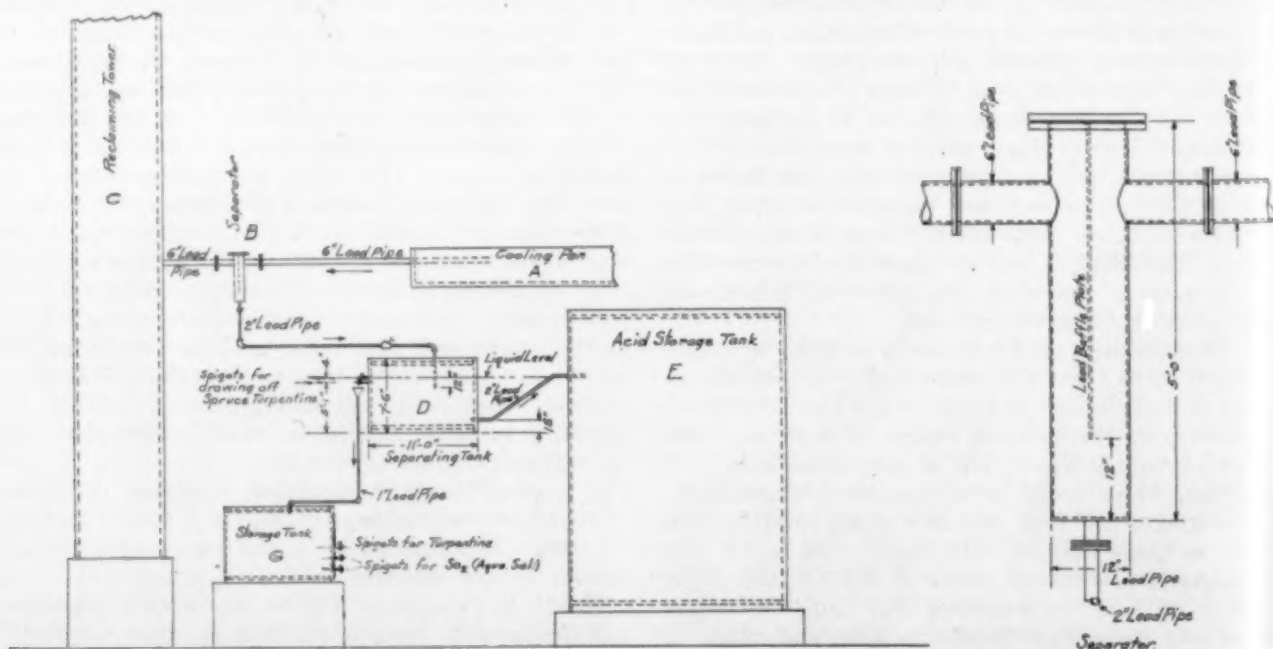


DIAGRAM OF METHOD FOR RECOVERY OF SULPHITE TURPENTINE, OR CYMENE, FOR TOLUOL MANUFACTURE

Hearings on Federal Water-Power Bill

Congressional Committee Is Enlightened on Provisions of New Measure Proposed by the Administration—Prospect Favorable for Enactment

WATER-POWER development under the terms of the so-called Administration bill was the subject of hearings last week before a special power committee of the House of Representatives. To those who have attended hearings in the past when similar measures were under consideration it was apparent that the prospect for successful legislation is now more favorable than at any previous time. There was a notable absence of the professional lobby, and the speakers who appeared before the committee presented sound and impartial facts. The attitude of the committee itself showed a desire to ascertain the truth in order that fair legislation might be speedily enacted. In short, the entire atmosphere was different to that of previous hearings, and there were evidences of unity of desire and purpose.

The course of the proceedings disclosed the particular features of water-power development in which different members of the committee are specially interested. Chairman Sims of Tennessee expressed regret that the bill did not contemplate securing revenue for the federal government, and repeatedly interrogated witnesses on the advisability of making such provision. He was unsuccessful in eliciting affirmative views. Congressman Taylor of Colorado asked all witnesses whether there existed such a thing as a water-power trust, and succeeded in reading into the record a complete denial of the existence of such a combination in the several states represented by the witnesses. Congressman Esch of Wisconsin reverted to parallel provisions in previous bills and interrogated witnesses on the relative merits of the different measures. In practically all cases the replies showed the superiority of the Administration bill.

Among the witnesses there was practical unanimity of opinion that the present bill is the best that has been proposed, and that with a few minor modifications it would be a workable measure. While it does not and will not contain everything that everybody thinks should be in it, there was expressed a willingness on the part of power men to accept the bill with slight modifications.

THE GOVERNMENT'S POSITION

Mr. C. O. MERRILL, chief engineer of the Forest Service, Department of Agriculture, stated the government's position on the measure. He spoke for the Secretaries of War, Agriculture and the Interior, who are named in the bill as a federal power commission. He spoke in part as follows:

"The industrial expansion caused by the demand for materials and supplies needed in the prosecution of the war, together with the huge financial requirements of the government, have materially changed the pre-war status of the electric power industry. The demand for power has increased notwithstanding increased costs of construction and operation. Increased operat-

ing costs have reduced the ratio of income to revenue, and this reduction combined with the decrease in supply of available investment capital has produced a situation with respect to public utilities, among which is electric power development, that merits the early attention of Congress."

He then reviewed the upward trend of prices for the past five years, showing the following advances: Hydraulic machinery, 100 per cent to 150 per cent; electric apparatus, 125 per cent to 150 per cent; steam turbine generators, 150 per cent; water-tube boilers, 170 per cent. In like manner the scarcity of labor and increase in wages have added to costs of construction. Encroachment on fuel-oil reserves and the scarcity of coal have their effect on power development, particularly on the Pacific Coast. All of these items have resulted in increased cost of steam power and have made hydroelectric development more attractive and more necessary.

MORE POWER NEEDED

"Notwithstanding increased costs of construction and of operation the demand for power has increased, not at a uniform but at an accelerating rate, until during the past two years the annual increment in power generated by commercial central stations alone has been from three to four billion kilowatt-hours, requiring an annual increase in installation of from one and one-half to two million horsepower.

"The demand for power will continue to increase while war continues, in order to supply power to our constantly expanding war industries; and when the war is over, to provide for the extension of public utilities and of the electrochemical industries, for electrification of railroads, and for the multitude of other activities that will accompany the period of reconstruction."

The difficulties in the way of financing power projects were shown by Mr. Merrill, who contended, however, that development could not stop and that legislation should be enacted which would offer the most favorable terms for new projects. He showed the necessity for increased efficiency in existing developments and the desirability of interconnection of isolated plants. In his opinion no considerable development of Eastern water-power will come about except through interconnection of plants over wide territories, in order that the diversity of demand may raise the load factor of the combined system to a point where steam-power competition can be met. This point was forcibly illustrated by a map of California, with its interconnected systems, superposed on the Atlantic States.

NEEDS OF THE FUTURE

The Administration bill gives consideration to the needs of the future, Mr. Merrill said, and anticipates the period of reconstruction after the war, when labor will be scarce and mechanical power in greater demand.

Our electrochemical industries, developing under the stimulus of war demands and the cessation of imports, will require increasing amounts of electric power if the United States is to take its place as a competitor in the world's markets or even supply domestic demands. Intensive studies should be made of power sites or groups of sites with relation to particular power needs. Mr. Merrill concluded:

"The shortage of fuel, the overloading of our transportation systems, the demand for industrial power and the unsatisfactory financial situation of our public utilities emphasize as never before the imperative need of immediate, adequate and comprehensive legislation. Our industrial efficiency, both during the war and thereafter, will be increased or diminished according to whether we do or do not make adequate provision for the development of our water-power resources. In view of these circumstances it is submitted that water-power legislation should be considered a war emergency measure and as such should be taken up by Congress and passed at an early date.

In response to questions by members of the committee, Mr. Merrill gave his opinion on the following points:

The terms of a license should be absolutely definite and unchangeable for the entire period of issue. This is quite necessary in order to prevent any uncertainty in the mind of the licensee as to the conditions under which he can operate.

The idea of the rental charge is not to secure revenue for the government, but it is made in return for the issuance of a license. The money thus received is to be used (1) to defray the cost of administration and (2) the possible necessity of recovering excess earnings which it is impossible to reach in any other way.

While the rentals should be nominal they should be greater in those cases where the government contributed land or some other tangible property to a project, and less where the government has nothing to offer but the license. Whatever provision is made should be clearly stated in the license before it is accepted by the licensee. It was Mr. Merrill's opinion that it would be a better fiscal policy to charge a rental which would be nominal and which would not reduce earnings below a fair return or increase rates to the consumer. As between getting revenue for the government and reducing rates to the consumer, rental charges should operate in favor of the latter.

Rate regulation on interstate business should be left to the several State authorities and handled locally as long as local authorities show the ability to act and as long as there is no disagreement between States. Federal jurisdiction should come in when other authority is insufficient.

The recapture clause is considered to be the most important in the bill, and it was Mr. Merrill's opinion that the basis for recapture should be the actual legitimate original cost of the property plus additions, less any funds accumulated in unappropriated surplus or for the purpose of providing for depreciation of equipment or amortization of investment. The price should allow nothing, however, for any unearned increment in value of the property, good will, going-value, or expected profit.

IMPROVING A NAVIGABLE RIVER

Mr. HENRY J. PIERCE of the Washington Irrigation & Development Company explained to the committee the features of a project for the development of power, improvement of navigation and irrigation of land at Priest Rapids on the Columbia River. This stream is now navigable for steamers of 1000 tons capacity for 400 miles from its mouth at the Pacific Ocean. The construction of a proposed dam and locks would add 200 miles of navigable waters, through a region almost without railroad facilities. The dam would cost \$25,000,000, and will permit of the development of 250,000 hp. throughout the year, and an additional 250,000 hp. or more during the high-water period. This period corresponds with the irrigation season, so that by a fortunate coincidence there would be water for irrigation and power for lifting it to the upper lands.

The witness showed a map of the United States and its navigable waterways. Practically all are in the East. On the other hand, 62 per cent of the area of eleven public-domain states in the West is under federal control, where over 60 per cent of the wasting water powers of the country are located. Mr. Pierce dwelt on the hazardous nature of waterpower undertakings and the necessity for removing onerous terms from licenses for development. In his opinion the bill under consideration was fair toward the investor and operator, while protecting public interest. He asked that a holder of a priority permit be protected in all expenditures made in good faith in the development of water power and that he be given the preference to a permit as against others who have not expended time nor money. He also asked that any tax imposed should be on the actual power developed, and that in case the license is to be renewed the original licensee have the first right.

Mr. CALVERT TOWNLEY, assistant to the president of the Westinghouse Electric & Manufacturing Company, repeated part of a statement made before the United States Chamber of Commerce. It was his opinion that even favorable legislation would not stimulate water-power development because of competition with the steam turbine and the comparatively low cost of construction of a steam-electric plant.

THE INVESTOR'S VIEWPOINT

Mr. E. K. HALL, vice-president of the Electric Bond & Share Company discussed the bill in its financial aspects. From the point of view of the investor there are two fundamental defects in the bill. The contract has been made definite and the investor knows what he is getting and what is expected of him. He is assured of the enjoyment of the privilege for fifty years and of the return of his capital at the end of that period if the government at that time wishes to recapture the project. But if the government does not want to take the property he must continue to run it under an indeterminate and uncertain tenure. He cannot issue refunding bonds, because he does not know how long he may be allowed to hold the property. For this reason Mr. Hall urged that if the government did not wish to take or transfer the property on the expiration of the license it should be reissued to the holder for a term of thirty years.

The other defect was the provision for recapture of

the property at the expiration of the license on payment of the net investment. This assured the investor the return of what he had put into the project and had not already taken out besides his fair profit, but did not allow him to profit by the enhanced value of the land. In all other businesses the investor was allowed, besides what fair current profit he could make, to benefit by an increase in the value of the property while in his hands. In response to an inquiry by a member of the committee, Mr. Hall said he considered this the best bill yet offered.

POWER DEVELOPMENT IN CALIFORNIA

Mr. JOHN A. BRITTON, vice-president and general manager of the Pacific Gas & Electric Company, showed the relation of hydroelectric development in California to the upbuilding of the state. He joined other witnesses in saying that the administration waterpower bill was good in its main features, but that some provision should be made to except from the full terms of the bill those projects which were only in part—and sometimes a very small part—constructed on government land. He cited two cases in California in support of his contention. In one case a reservoir project includes 38 acres of "forest reserve," which is really a rocky, barren waste, but which is flooded when the reservoir is full. In another projected development of 250,000 hp., less than 2 per cent of the land belongs to the government, and yet if the project is developed in such a way as to omit this 2 per cent, there would be a large loss in potential power. It would be criminal not to develop the full amount of power, and yet the obligation that would result under present rules and regulations of the departments would prevent financing the project. Mr. Merrill had previously suggested the following amendment to the bill to cover such cases as Mr. Britton spoke of.

"In issuing licenses for a part only of a complete project, or for complete projects of not more than 50 hp. capacity, the commission may, in its discretion, waive such conditions, provisions, and requirements of this act as it may deem equitable in the circumstances."

Mr. Britton laid stress on the necessity of hydroelectric development as a measure for conservation of coal or oil—resources which are destroyed when used once, as against the perennial and inexhaustible use of waterpower. He showed that the licensee can get only a fair return on his investment, and not even that unless he makes a success of the venture. In the latter case the government has an opportunity to recapture the project, and perhaps turn it over to a municipality.

Mr. H. T. FREEMAN of the Connecticut River Company showed the necessity for government action if such projects as those of his company are to come to fruition. He was asked if a waterpower trust existed in Connecticut, and replied that, on the contrary, there was the keenest competition.

Mr. JOHN J. HARRIS, president of the Big Horn Canyon Irrigation & Power Company, Montana, described his project, which combined the features of power development, flood control, transportation and irrigation. He thought that local organizations of men with small resources might be handicapped by the provision of the bill allowing only three years for preliminary work on a project. He showed the committee

what such preliminary work meant to his concern, which had been engaged for six years.

MR. CHARLES N. CHADWICK spoke in behalf of House Bill 9681, which seeks to provide for a broad administration of national water resources. It calls for a national board of water conservation to study rainfall, flood control, navigation and power development. Mr. Chadwick felt that this bill affords a better opportunity for broad treatment of the subject than does the administration water-power bill.

Mr. C. F. KELLEY, counsel for the Montana Power Company, said that the Administration bill was generally acceptable as a measure that would encourage the development of water-power. He objected to recapture on the repayment of "net investment" to the licensee, and asked for "just compensation." Mr. Charles E. Stuart of the United States Fuel Administration told the committee of the efforts of the Administration to conserve fuel.

MR. A. P. MORRISON of the Electro Metallurgical Company, Niagara Falls, spoke from the viewpoint of the large user of power, to whom stability of service and rates were of prime importance. He felt that such consumers were not sufficiently protected in the bill. Their investment might easily be greater than that of the licensee, and yet at the expiration of the license they might be subject to readjustments in rates that would be prohibitive.

MR. A. H. HOUGHTON of the Conservation Committee of New York thought there would be some conflict between the Administration bill and the New York laws, and suggested amendments. The term of five years for the executive officer of the federal commission should be changed to ten or fifteen years. Mr. William B. Matthews of Los Angeles, which has its own municipal plant, said that a license to a municipality should be perpetual. The federal commission should not have jurisdiction over rates and service of a municipal corporation where power is used for state or municipal purposes.

SECRETARY LANE ADVOCATES IMMEDIATE DEVELOPMENT

Secretary Lane of the Interior Department was an important witness toward the close of the hearings. He pointed out that there is still on the books a statute under which revocable permits are granted, but that the men who have money to invest in water-power propositions are not willing to allow any official to say when the investment they have made shall be thrown to the winds. The result, he said, has been that we have stood for five years almost entirely without development of one of our great resources.

The secretary then cited the interdependence of the West and the East in water-power development. As an example he gave the recent action of the Anaconda Copper Mining Co. in undertaking the manufacture of ferromanganese. This was made possible by the development of water power in Montana near deposits of low-grade manganese ores. The effect of this single development had been to release shipping formerly used in bringing manganese to this country, but now available for war business. Furthermore, ferromanganese manufactured in Montana was used directly in the industries of Pittsburgh.

"If we had money enough," he continued, "if this were not a time of war, if we could think in the terms

of money that we are now thinking in, or if, four or five years ago, Congress had been willing to expend hundreds of millions of dollars in the development of water power as it is forced now to spend billions of dollars for war, it would be a wise thing to put a large part of the public revenues into such projects where they are found to be needed.

GOVERNMENT OWNERSHIP FEASIBLE

"I have no doubt in my own mind but that such schemes as water-power schemes are perfectly practicable from a governmental standpoint, no matter what your sympathies may be respecting government ownership, as a rule, of large utilities. A thing that is as well standardized as a water-power scheme can be operated successfully by the Government; but I do not take it that this is a practicable proposition at this time, nor probably will it be for many years to come, and it is necessary that there should be real development, and that soon." Mr. Lane elaborated his point of view in regard to the impracticability of devoting Government funds at this time to the building of water-power plants by discussing the immense demands being made upon the treasury now and in prospect.

Answering questions by Chairman Sims, Secretary Lane said if there is a determination by Congress that there shall be water-power development, for instance, along the Columbia River, or the Snake River, or the Colorado River, for the production of low-grade manganese, or for the development of nitrates, either for gunpowder or for fertilizer, and such works could not be financed, that "it is the duty of the Federal Government at this time to help out the proposition and put it on its feet." He added: "I am not sympathetic generally with the idea of having the Government lend money to private enterprises, because it is a hard thing to get it back. But I am very much in sympathy with the Government doing what it pleases with its own money, provided it knows where it is going and what it wants and how that money can be properly handled; and I am not afraid at all of the Government undertaking the development of the water-power propositions, because we have had some experience with them in the Reclamation Service. The Salt River proposition which I have turned over to the water users is practically paying its own way now out of the power developed at the Roosevelt dam. That was a venture at the time. All of these propositions are gambles. That is one reason why a man who puts his money into a water-power project has got to have very real consideration. He is a developer, and every man who is a pioneer of any kind takes the risk, and for his risk he ought to be compensated."

In reply to a question as to whether it will be possible for water-power plants to be built in time to be of service before the war is over, Secretary Lane said: "I have no expectation that this war will be over before water-power projects such as many that we know of can be developed. I think you have got to look at that thing with a long range."

EXPANSION PREDICTED IN ELECTROCHEMICAL INDUSTRIES

Secretary Lane predicted a great expansion of the electrochemical industries of the United States. "We ought to appreciate more fully now that after this war is over there will be the necessity of larger electrical devel-

opment than we have ever had before in connection with the chemical industries of the United States.

"We have never been a chemical nation, and that side of our scientific development has been overlooked. Germany has been the chemical nation of the world. We are now taking that up, and probably there is more interest today in chemistry in the United States than there has ever been before. We have in Washington today hundreds of chemists working in connection with the Bureau of Mines and the Ordnance Department. They have been gathered from all parts of the country. A great many of them are Germans, many of them educated abroad in German institutions, showing how far ahead Germany has been in this particular line of science. It is quite manifest to me that there has got to be very large hydroelectric development if we are going to develop to the highest degree along the lines of chemistry. Perhaps the best sphere for a young man for the next twenty-five years will be as an electrochemical engineer in the United States. The water powers ought to be developed now, not only with the idea of taking care of a process that is a commercially successful proposition, but for the purpose of experimenting and discovering what can be done. We ought to foster that kind of thing."

United States Chamber of Commerce Referendum on Water-Power Legislation

The Chamber of Commerce of the United States announces the results of a referendum to more than 1000 commercial organizations on a series of recommendations relating to water-power development. The following recommendations were approved by sweeping majorities:

That federal legislation encouraging the development of waterpowers should at once be enacted; that authority to grant permits should be vested in an administrative department; that the permit period should be at least fifty years, any shorter period being at the applicant's option; that tolls should attach only to use of public lands or benefits derived from headwater improvements; that permittees should be entitled to acquire the right to use public lands forming only a small and incidental part of the development; that recapture should be exercised only upon payment of fair and just compensation; that, if recapture is not exercised, the investment of the permittee should be adequately protected; that rates and service should be regulated by State commissions where the service is intrastate, with federal regulation only where several States are directly concerned and do not agree, or there is no State commission; that if any jurisdiction to regulate the issuance of securities is exercised it should be solely by the State; that no preference should be granted as between applicants amounting to a subsidy from the Government creating unequal competition.

These provisions are practically contained in the Administration bill now before the special waterpower committee of the House. They were regarded as the vital points on which there might be a difference of opinion, and in sending out the referendum the Chamber was careful to present arguments for and against each of the ten items. Consequently the vote may be considered indicative of intelligent opinion formed by the business men of the country after a careful study of the subject. Some negative votes were cast on each item, but the number was insignificant and the net result may be looked upon as a unanimous demand for the development of water power and approval of the proposed procedure.

Standardization of Rare-Metal Thermocouples*

BY PAUL D. FOOTE, T. R. HARRISON and C. O. FAIRCHILD

United States Bureau of Standards

MANY technical industries use such extensive installations of pyrometer equipment that it is frequently desirable to place the general supervision and maintenance of this equipment in the hands of a technical expert. The duty of this engineer and his assistants is to calibrate the instruments, check frequently the accuracy and constancy of the pyrometers, make small repairs, construct thermocouples, and install new apparatus when required. He should be familiar with all methods of temperature measurement, temperature control, etc., and various chemical and metallurgical processes, so that he may suggest advisedly new methods and improvements in temperature measuring apparatus for the particular process in question.

A man of the required ability will necessarily command a good salary, but it has been the experience of many companies that it is poor economy to place work of this character in the hands of inexperienced men. If it is believed that a perfect working system of temperature control can save a certain plant any considerable sum each year, a fair percentage of this amount can be profitably spent in securing a competent, technically-trained man and in equipping a modern laboratory for the maintenance of the pyrometer installation. With the proper organization and equipment, exceedingly valuable investigational work may be carried on, new opportunities will be found for increasing the value and uniformity of the finished product and the cost of production may be lowered by reducing the number of failures to a minimum.

TYPE OF TESTS PERFORMED IN THE INDUSTRIAL LABORATORY

The modern industrial plant employs various types of pyrometers including the high-temperature mercury thermometer, the resistance thermometer, the radiation pyrometer, the optical pyrometer, and the thermocouple, etc. Each type of instrument has its advantages for various processes. The calibration, upkeep and use of each class of instrument should be carefully considered.

The present paper deals with the laboratory side of one phase of this problem, namely, thermocouple installations. This is, however, probably the most important subject with which the pyrometer laboratory has to deal. The calibration of optical and radiation pyrometers requires rather elaborate equipment and is so susceptible to errors that this type of testing is usually not advisable for the ordinary technical laboratory. It is better to send such instruments to the maker or to the Bureau of Standards for calibration. Furthermore, the number of calibrations of optical or radiation pyrometers required per year by any one company is, in general, comparatively small since these instruments

do not deteriorate with use as do thermocouples. A single calibration of a good optical or radiation pyrometer should hold for years if the instrument is properly cared for. On the other hand, the calibrations of the thermocouples must be repeatedly checked, for contamination and use may alter the temp.-e.m.f. relation, and the life of base metal couples is frequently so short that the calibration of new couples becomes a serious problem in the case of large installations.

Thermocouple testing may be divided into two general classes, primary standardization and secondary standardization. In primary standardization the thermocouple is calibrated directly in terms of certain fixed temperatures, defined by the melting or freezing points of a series of chemically pure metals. In a secondary standardization the couple under test is compared with another couple which has been calibrated as above. Primary standardization is not recommended for most industrial laboratories, as it requires a considerable amount of extra apparatus and laboratory technique. The Bureau of Standards undertakes work of this character for a nominal fee and recommends that the industrial laboratory maintain at least two standard rare-metal couples, which may be submitted to the bureau at intervals for a primary calibration. All the couples are then calibrated in the industrial laboratory by comparison with these standards. However, a number of companies prefer to do their own primary standardization and for this reason the best methods for primary calibrations as well as secondary calibrations are discussed below.

STANDARDIZATION OF RARE-METAL COUPLES

The rare-metal couple may be purchased completely mounted in a porcelain or quartz tube with the cold junction arranged to operate at room temperature or at the temperature of melting ice. The latter method is preferable for the highest accuracy, but the former method is usually sufficient for most requirements. A suitable ice box is described later.

If desired, the thermocouple wire may be purchased from the platinum refiners and made into couples in the laboratory. One wire should be platinum and the other an alloy of 10 per cent rhodium with platinum, both of the highest possible purity. For general work, wires 0.5 mm. or 0.6 mm. in diameter and 100 cm. long serve satisfactorily. A shorter length may be used if the cold junction is operated at room temperature or in connection with the compensating leads to be described in a later article in a paragraph on cold junctions.

The hot junction is formed by fusing the two wires in an oxy-gas flame or small electric arc. With a little practice a neat joint can be made which should be in the form of a bead about 1 mm. diameter. The wires are threaded through two-hole porcelain insulators and placed inside of a thin-walled protecting tube of quartz or of porcelain, glazed on the outside only. The two

*The first of a series of two articles dealing with the pyrometer laboratory for industrial purposes. The second article will deal with base-metal thermocouples.

free ends of the couple are mounted in the ice box (See section on cold junction ice box) and from this point copper leads are carried to the potentiometer.

ANNEALING

Before standardization the couple should be removed from the mounting and the entire length of wire electrically annealed for a few minutes at about 1500 deg. C. This treatment eliminates the electromotive forces which otherwise would be developed between the hard and soft portions of the wire. When rare-metal couples have been contaminated by long continued use they may be often restored to their original condition by annealing for an hour or more at this high temperature. Impurities, such as iron oxide, which have accumulated on the surface of the wires may be removed by 50 per cent nitric or hydrochloric acid. In case long-continued alternate heating and treatment with acid fail to restore sections of the couple, these badly contaminated portions should be cut out and the couple fused together again with as small a junction as possible.

For annealing electrically the couple is suspended between two binding posts and sufficient current passed through it to raise the temperature of the wire to about 1500 deg. C. A couple made of wires 0.6 mm. in diameter requires about 14 amp., 0.5 mm. about 12.5 amp. and 0.4 mm. about 10 amp.

In general the contaminated portions do not glow as brightly as the more pure sections of the wire. If the wire is not badly contaminated the darker spots will gradually disappear. If more extreme local treatment is required, the contaminated portions may be wound into a small spiral and the couple heated as before. The coiled portion of the wire loses less heat per unit length by radiation and hence can be maintained at the desired temperature while the rest of the wire is heated to a dull red. Usually foreign matter produces a gray or dark appearance of the wire when cold, and these contaminated sections are stiffer than the uncontaminated wire.

While couples may be often restored to their original condition by annealing, the disappearance of the gray spots on the wire does not prove absolutely that the couple is free from contamination. The absence of contamination is shown, however, by a homogeneity test. Where high accuracy is required a homogeneity test should be made.

HOMOGENEITY TEST

For work of precision each wire of the couple must be uniform in chemical composition and physical condition throughout its entire length. The magnitude of the e.m.f. developed by the couple depends upon the composition of the couple in the region of the temperature gradient. The e. m. f. developed by an inhomogeneous couple is not necessarily a measure of the temperature of the hot junction. In fact it is a measure of the temperature of the hot junction only when the region of inhomogeneity lies entirely outside of the region of temperature gradient. Such a fortunate condition would be obtained very rarely in practice.

Suppose, for example, in a furnace 40 cm. long, that the temperature is uniform and at 1000 deg. C. over the central 20 cm. of the furnace and that the temperature drops, linearly with distance, to 0 deg. C., over the remaining 10 cm. on each side. Omitting consid-

eration of conduction losses, a homogeneous couple would show the true temperature of any desired portion of this furnace, and the temperature indicated would be that corresponding to the position of the hot junction of the couple.

Consider the use of an inhomogeneous couple in which the wires are badly contaminated for a length of 5 cm. from the hot junction. This couple would give the correct temperature of the central portion of the furnace when immersed to any depth between 15 and 30 cm. because for such depths of immersion the inhomogeneous portion of the couple lies wholly within the region of temperature uniformity. It would not be possible to measure with this couple the temperature of any portion of the furnace less than 15 cm. from the outside because the region of inhomogeneity would lie in the region of temperature gradient. Under such conditions the couple acts as a compound or differential couple and it is impossible to predict how much in error its indications may be since the magnitude of the error depends upon the amount of contamination and the steepness and location of the temperature gradient.

The above example illustrates the fact that the reading of an inhomogeneous couple depends upon the depth of immersion and does not, except by accident, indicate the temperature of the hot junction. It would be impossible to measure, by means of an inhomogeneous couple, the temperature of any portion of a furnace which was non-uniformly heated, unless the couple were calibrated in the position used.

For a homogeneity test a short length of each thermocouple wire is selected as a standard reference specimen. These lengths may be cut from the uncontaminated cold-junction ends of the couple and one set may be used repeatedly for various couples of the same type. One end of the standard wire (for example the pure platinum wire) is touched to a section of the corresponding wire of the thermocouple and the e.m.f. is observed between the cold-junction end of the thermocouple wire and the free end of the standard wire when the point of contact between the standard and the thermocouple is heated to some convenient high temperature, maintained constant.

The point of contact of the two wires is then moved to a different section of the thermocouple wire and the process continued until the platinum wire of the thermocouple is completely explored. The process is repeated for the alloy wire of the couple, except that in this case the specimen of the alloy wire is used as the standard.

If e is the maximum difference in microvolts between the two readings of e. m. f. made along one wire of the thermocouple and s the value of the thermoelectric power for the couple (microvolts per degree of temperature) then the maximum error usually possible in the use of the couple due to inhomogeneity of this wire is e/s in deg., provided the temperature of the hot junction in general use does not exceed that employed in the homogeneity test.

If the temperature difference between the hot and cold junctions during the homogeneity test were $t_1 - t_2$, and during the actual use of the couple $t'_1 - t'_2$, the maximum error possible in the use of the couple, due to inhomogeneity of this wire, is approximately $\frac{t'_1 - t'_2}{t_1 - t_2} \frac{e}{s}$ degrees. Similar conditions hold for the other wire of the couple.

The effects of inhomogeneity in both wires may be either subtractive or additive so that it is evident that to quantitatively correct temperature readings for errors due to inhomogeneity is practically impossible. Merely qualitative results can be obtained from tests of this nature. If the variations in e.m.f. observed during the homogeneity test are less than 5 microvolts for $t_1 - t_2 = 500$ deg. C., the couple can be relied upon for precision work. If certain sections of the couple show larger e. m. f. these sections should be treated by annealing until their condition is satisfactory, or should be cut away in case they cannot be brought to a proper condition.

The point of contact between the couple wire and the standard wire may be heated by a Bunsen flame, but a more satisfactory method is as follows: The heater consists of a glass (preferably pyrex glass) T tube having the top and leg of the T wound with resistance wire through which sufficient current is passed to heat this tube to about 400 deg. C. One of the wires of the thermocouple is threaded through the top of the T and the standard wire is brought into contact with the couple by threading it through the lower part of the T. The end of the standard wire is bent into a small hook

through which the couple passes, sufficient tension being given to the standard wire to secure good electrical contact with the couple. The free ends of the

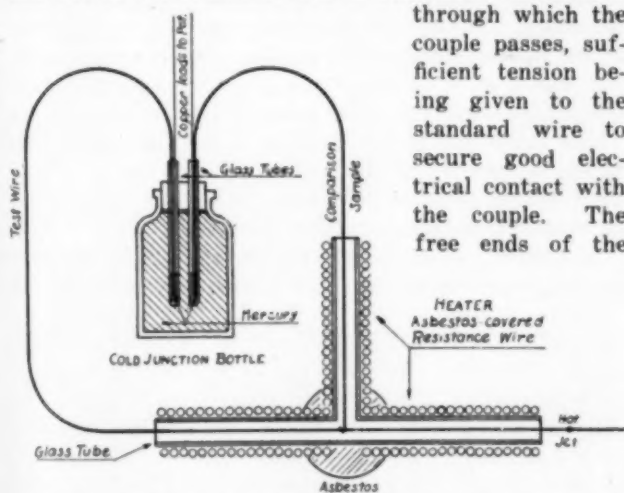


FIG. 1. APPARATUS FOR HOMOGENEITY TEST OF RARE METAL COUPLES

couple wire and the standard are maintained at the same temperature by use of a cold-junction box.

The cold-junction box may consist of a small bottle of mercury into which dip two small glass tubes closed at the lower end. A few drops of mercury are placed in each tube and the free end of the couple wire is inserted into one tube and free end of the standard into the other tube. Copper wires making contact with the platinum wires by means of the mercury inside the tubes lead to the millivoltmeter or potentiometer. The copper and platinum must not come in electrical contact except in the mercury. Readings of e. m. f. are made for various points of contact along the couple by pulling the couple through the T tube and allowing a minute or so for temperature equilibrium at each new position. Figure 1 illustrates the apparatus used for homogeneity tests.

THE LABORATORY POTENTIOMETER:

In precision thermocouple calibration a potentiometer especially designed for this type of work should be used.

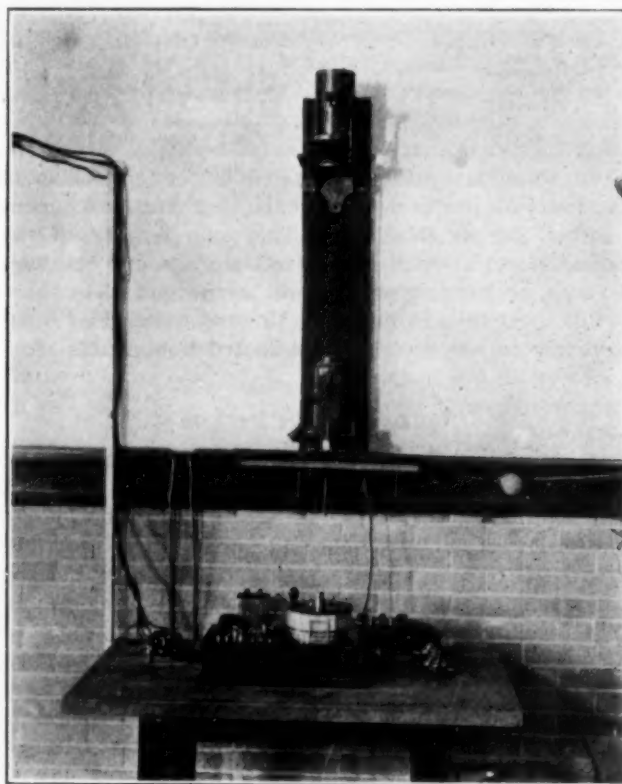


FIG. 2. A LABORATORY POTENTIOMETER AND ACCESSORIES

Figure 2 illustrates a complete potentiometer installation, including galvanometer and reading scale. The wiring diagram is given in Figure 3.

In order to eliminate the effect of accidental thermal e.m.f.'s developed in the instrument itself two double-pole double-throw switches are used, one in the main battery circuit and one in the e. m. f. circuit. Readings are made with the two switches thrown first in one direction and then in the other direction. In one case the parasitic e.m.f.'s arising in the potentiometer and galvanometer are additive to that of the couple and in the other case they are subtractive, whence a mean of the two readings gives the true e. m. f. of the thermocouple circuit. In comparing the e.m.f.'s of two or more couples, readings should be taken in the following order and the final means obtained, used as the calibration data.

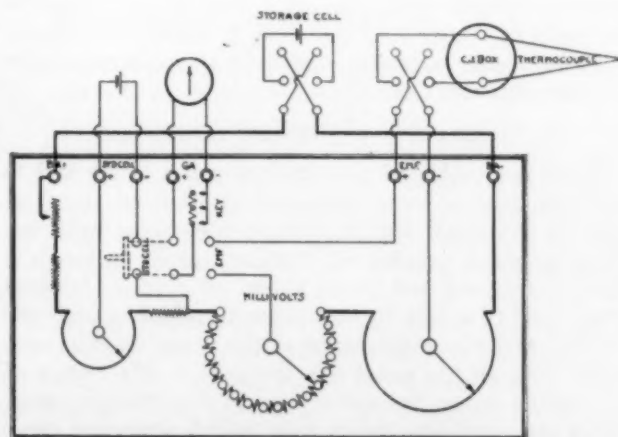


FIG. 3. WIRING DIAGRAM OF POTENTIOMETER INSTALLATION

| Position of Switches | Couple I | Couple II | Couple III |
|----------------------|-----------|-----------|------------|
| Normal | 1 | 2 | 3 |
| Reversed | 6 | 5 | 4 |
| Normal | 7 | 8 | 9 |
| Reversed | 12 | 11 | 10 |
| | mean emf. | mean emf. | mean emf. |

Care should be taken that the battery switch is in the normal position when balancing the instrument against the standard cell. The main battery of the potentiometer should be a 2-volt storage cell of about 50 amp. hr. capacity and should be charged every three months. Details in regard to the use and care of a potentiometer are given in the instruction manual furnished with the instrument.

COLD-JUNCTION ICE BOX

A satisfactory ice box is obtained by fitting a small battery jar with a fiber or hard rubber cover. Through the cover are inserted several small glass tubes closed at the lower end, two tubes for each couple used. A few drops of mercury are placed in each tube and the battery jar is kept filled with clean ice shaved or ground into a wet snow.

The cold junction ends of the couples are inserted, one in each tube, and copper wires lead from the mercury to the potentiometer. The copper wires should be insulated from the couple wires throughout the length of the glass tubes except where they dip into the mercury. This precaution is very important, for if the copper and platinum (or alloy wire) are in electrical contact at the top of the glass tubes, the whole value of the ice box is lost.

The glass tubes should be kept clean and dry inside. A little moisture and dirt at the bottom of the tube will form a galvanic cell giving a large e. m. f. This trouble is easily detected by the rapid change in e. m. f. immediately after closing the potentiometer key, due to the polarization of this small cell. It is desirable, but not necessary, to replace the battery jar by a Dewar flask or thermos bottle having a large mouth, since the ice melts more slowly in this form of container. Figure 4 shows a diagrammatic sketch of an ice box suitable for thermocouple work.

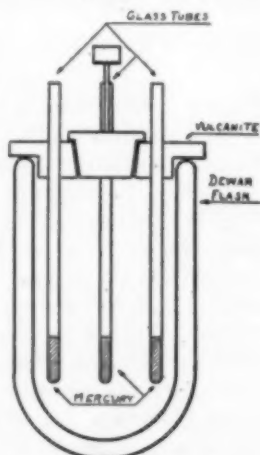


FIG. 4. THERMOCOUPLE ICE BOX

CALIBRATION OF PRIMARY STANDARDS

When a crucible of pure molten metal is allowed to cool, the cooling curve obtained by plotting temperature of the metal versus time is continuous until the freezing point (or transformation point) is reached. During freezing the metal gives out enough internal latent heat to supply the losses due to radiation and convection, and the temperature of the metal remains constant until all the metal has frozen. In this region of the cooling curve, the curve is parallel to the time axis. After the metal has frozen it cools in a somewhat similar manner as when completely molten. Figure 5 shows cooling and heating curves for several metals.

The freezing point of copper (1083 deg. C.) is clear-

ly indicated by the flat portion of the second curve. On heating a metal the temperature gradually increases with time until the melting point is reached. The temperature of the metal then remains constant, as shown in Figure 5 until all the metal is melted, after which the temperature again increases with time.

The temperatures at which melting and freezing occur are identical for pure metals. When molten antimony is allowed to cool the temperature usually falls below the freezing point before the metal starts to freeze, a phenomenon known as under-cooling. When any of the metal starts to solidify, however, the temperature immediately rises to the freezing point as shown in Figure 5, unless the under-cooling has proceeded too far. Under-cooling may be greatly reduced by stirring the metal for an instant just as the freezing point is approached.

Aluminium does not appear to have as well defined a melting or freezing point as do many other metals. The material is "pasty" over a small temperature range. This may be due to the presence of impurities and is probably not a characteristic of the pure metal.

In the primary calibration of rare-metal couples use is made of the type of cooling and heating curves above described. The couple, properly protected, is immersed in the molten metal which is then allowed to cool slowly. The e. m. f. of the couple is observed as frequently as possible and the time noted for each observation. These values are plotted and the e. m. f. corresponding to the flat portion of the cooling curve is the e. m. f. at the freezing point of the metal. A similar process may be carried through by melting the metal.

The temp.—e. m. f. relation for the platinum, platinum-rhodium couple has the following form: In the

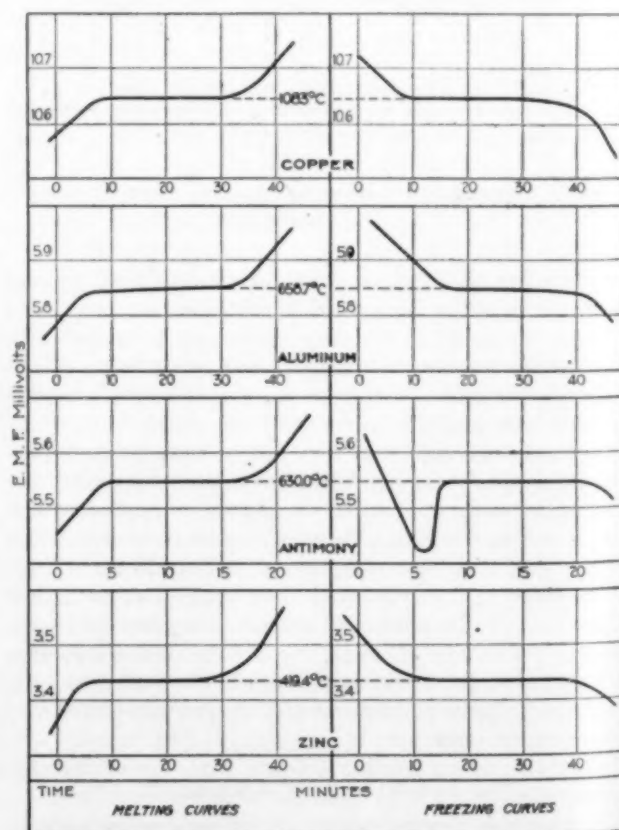


FIG. 5. TYPICAL HEATING AND COOLING CURVES

temperature range 300 deg. to 1200 deg. C., $e = a + bt + ct^2$ where $e = e. m. f.$, $t = \text{temp. deg. C.}$ of the hot junction of the couple (cold junction = 0 deg. C.), and a , b , and c are constants. Three standard points are required to determine a , b , and c for any particular couple. These fixed temperatures may be the melting or freezing points of zinc 419.4 deg. C., antimony 630 deg. C., or aluminium 658.7 deg. C. and copper 1083 deg. C. The metals must be of the highest possible purity. This is especially the case with antimony, which is very difficult to obtain in sufficient degree of purity. The Bureau of Standards furnishes standard samples of zinc, aluminium, and copper (also tin, see Circular No. 66), with certified melting points. Aluminium of the highest obtainable purity is recommended in preference to antimony for the industrial laboratory. The following shows the method of obtaining the constants a , b and c :

| OBSERVED CALIBRATION POINTS | | |
|-----------------------------|-------------|------------------|
| Metal | Temperature | emf. |
| Zinc | 419.4°C | 3.436 millivolts |
| Aluminium | 658.7 | 5.839 |
| Copper | 1083. | 10.561 |

Whence, from the above equation it follows that:

$$3.436 = a + (419.4)b + (419.4)^2c.$$

$$5.839 = a + (658.7)b + (658.7)^2c.$$

$$10.561 = a + (1083)b + (1083)^2c.$$

These three equations are solved for a , b , c , giving $a = -0.3240$, $b = +0.008277$, $c = +0.000001638$. The final equation for this couple thus becomes:

$$e = -0.3240 + 0.008277t + 0.000001638t^2$$

where e is the $e. m. f.$ in millivolts corresponding to a hot-junction temperature of t deg. C., and a cold junction temperature of 0 deg. C. From this equation e may be computed for various values of t deg. C., (for example 300 deg. C. = 2.306 millivolts; 350 deg. C. = 2.774; 400 deg. C. = 3.249; 1200 deg. C. = 11.967, etc.) and a curve or table of e versus t deg. C. may be constructed. Using this curve or table one may readily find the temperature corresponding to any $e. m. f.$ observed in the future use of the couple.

The above equation serves to determine the temperature scale in the interval from 300 deg. C. to 1200 deg. C. An entirely different equation must be used for points below 300 deg. C. For discussion of this see Burges and LaChatelier "Measurement of High Temperatures." At temperatures higher than 1200 deg. C. the following corrections must be added to the temperatures given by the above equation. These corrections apply for all platinum—ninety platinum—ten rhodium, thermocouples.

| Temperature computed from parabolic equation | Correction to add |
|--|-------------------|
| 1200°C | 0°C |
| 1300 | 2 |
| 1400 | 6 |
| 1500 | 14 |
| 1600 | 25 |
| 1700 | 37 |

The standard metal may be used in an Acheson graphite crucible (Dixon graphite is also satisfactory for copper) the inside diameter of which is slightly less at the bottom than at the top. Convenient inside dimensions are about 5 cm. diameter and 15 cm. deep. For use with the 50 cm. 3 metal samples furnished by the Bureau of Standards a crucible 3.5 cm. inside diameter and 8 cm. deep is recommended. Crucibles should be fitted with a cover having a small hole in the center

through which the couple is inserted. The crucible may be heated either in an electric or gas furnace. Figure 6 shows a convenient form of electric furnace. The bottom of the furnace must be tightly closed with asbestos wool as the slightest current of air will rapidly oxidize the crucible. If this simple precaution is omitted, in a very short time the bottom of the crucible will burn completely away allowing the metal to run out and become contaminated. Also the furnace will be seriously damaged by the molten metal.

If a gas furnace is used the crucible should be placed inside a length of iron pipe, capped at the bottom, and

the space between the crucible and the pipe should be filled with powdered or flaked graphite. Instead of an iron pipe, a larger crucible of Dixon graphite or fireclay may be used. In all cases the top of the crucible and the surface of the metal should be covered with 2 or 3 cm. of powdered or flaked graphite. This is especially important with copper, as the oxide of copper formed on exposure of the hot metal to the air is soluble in the metal and thus lowers the melting point to an appreciable extent.

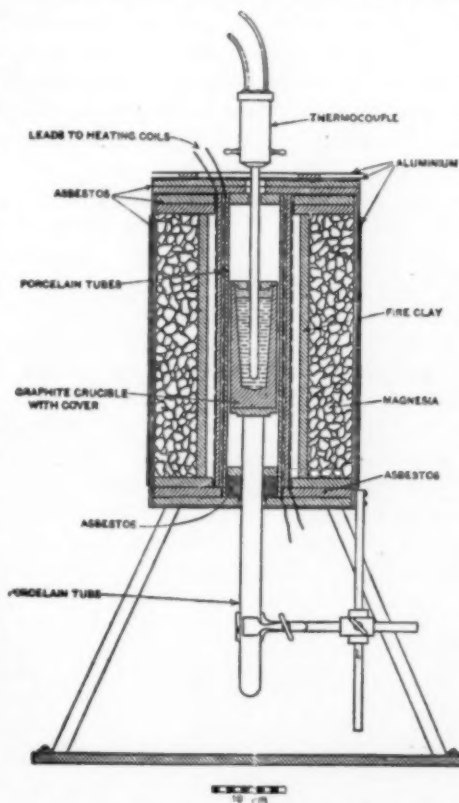


FIG. 6. ELECTRIC FURNACE FOR STANDARDIZING THERMOCOUPLES BY MELTING-POINT METHODS

PROTECTING TUBE FOR RARE-METAL COUPLE

The thermocouple must not come in direct contact with the molten metal or metallic vapors. A suitable protecting tube is of porcelain glazed on the outside and closed at the lower end. The diameter of the tube may be 1 cm. or less and the walls should be thin. The couple wires are again protected and insulated from each other by small porcelain insulating tubes, or by the standard two-hole porcelain tubing sold for this purpose.

It is good practice to remove the couple and insulators from the outside protecting tube when immersing the latter in the molten metal as frequently the tubes are broken in this operation. This precaution saves the couple in case such an accident takes place. The procedure is therefore as follows: Hold the pyrometer tube above the furnace in the heated air until it takes up this temperature. Gradually lower it into the furnace

until the top of the crucible is reached. When thoroughly heated gently immerse it in the metal. Observe that the tube is not broken. If in doubt insert a small porcelain tube inside the pyrometer tube. If the outer tube is broken the small tube will be discolored or contaminated with the metal. Another method of detecting a broken tube is to pull it out of the metal and if intact replace it before it has had time to cool. After having determined that the pyrometer tube is good, insert the thermocouple. This should be done very slowly as the rapid insertion of the cold thermocouple may break the protecting tube. After the metal has frozen the protecting tube should be withdrawn or the furnace should be immediately heated for a melting point determination. An immersed tube which is allowed to cool with the metal far below the melting point is usually broken. For a small temperature range below the melting point the tube can be readily withdrawn.

Either glazed porcelain or fused quartz (silica) protecting tubes may be used in this work. With aluminium, however, the protecting tube must be itself protected from the metal. This is easily done by making a tubular sheath of Acheson graphite, with walls about 1 mm. thick, which slips over the quartz or porcelain tube. It is better to have one set of tubes for each metal, but when necessary to use the same tube in various metals this can be done if care is taken to thoroughly clean the tube with nitric and hydrochloric acid. The greatest care should be exercised to see that no dirt of any kind gets inside the pyrometer tubes. Dust or carbon inside the tubes, when heated, forms a reducing atmosphere which acts upon the silica, freeing silicon which rapidly attacks the platinum.

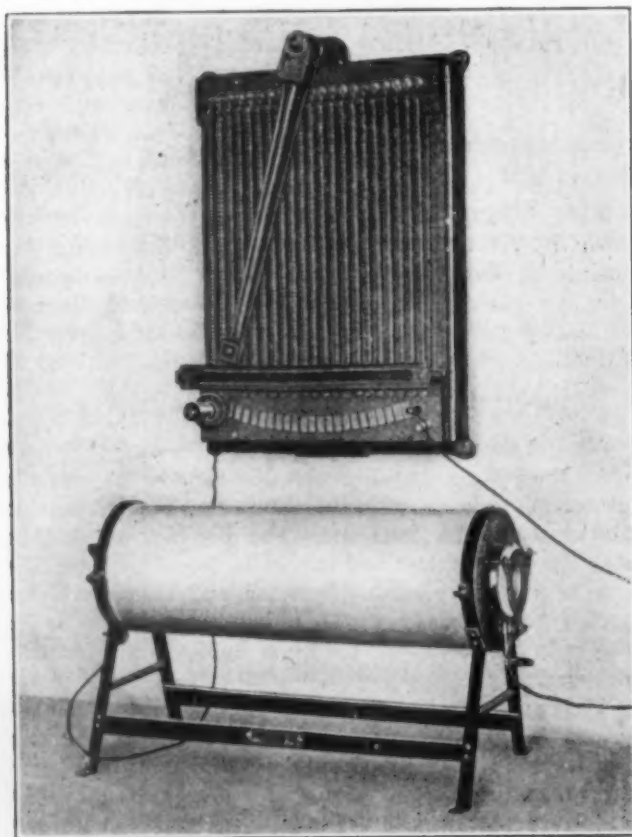


FIG. 7. CONVENIENT FORM OF ELECTRIC FURNACE FOR INTERCOMPARING RARE METAL COUPLES

SECONDARY OR COMPARISON CALIBRATION OF RARE-METAL COUPLES

The secondary method, as follows, is recommended for industrial laboratories. One or preferably two rare-metal couples of wire about one meter in length and 0.6 mm. in diameter are maintained as primary standards. These couples should be submitted to the Bureau of Standards for test and certification at intervals depending upon the amount of use to which they are put, or whenever contamination is suspected. The couples to be tested are compared with these standards. Suitable electric furnaces for such comparison tests are now available, designed to operate on either 110 or 220 volts and may be obtained complete with adjustable rheostat for regulating the current, as shown in Fig. 7. The furnace consists of a porcelain tube wound with platinum foil, surrounded by a larger porcelain tube around which is packed thermal insulating material. A convenient size of heating tube is 1 in. by 18 in., but larger sizes can be secured if desired. The furnace should be kept clean and should not be used for testing base-metal couples, annealing iron rods, or other processes likely to cause contamination.

The rare-metal couples to be calibrated are removed from the protecting tubes and insulating tubes and annealed as described previously. The insulating tubes are then replaced and the couples are tested without the protecting tubes, if the furnace is clean. The hot junctions of all the couples, the standard couple and the couples under test, are connected together with as good thermal contact as possible. The junction may be fastened together with a small platinum wire and then wrapped with platinum foil. Since the couple wires are thus in electrical contact at the hot junction, they must not be allowed to touch one another at any other point. The use of platinum foil around the hot junction is to reduce temperature gradients to a minimum. If the couples are tested in the protecting tubes, this precaution becomes still more important.

The cold junctions of all the couples are maintained at 0 deg. C. If three couples are being compared with one standard, the readings should be taken in the following order:

| Reversing Switch | Standard | No. 1 | No. 2 | No. 3 |
|------------------|----------|-------|-------|-------|
| Normal | 1 | 2 | 3 | 4 |
| Reversed | 8 | 7 | 6 | 5 |
| Normal | 9 | 10 | 11 | 12 |
| Reversed | 16 | 15 | 14 | 13 |
| Means | — | — | — | — |

The means of the observations on each couple are taken and the temperature is obtained from the reading of the standard couple. Several calibration points are made in this manner in the range 300 deg. C. to 1200 deg. C. These are plotted, temp. vs. e.m.f. and a smooth curve is drawn through the experimental points for each couple. If it is inconvenient or undesirable to use a cold junction temperature of 0 deg. C. for the couples under test, any other constant temperature may be employed. This can be measured by means of a mercury thermometer. It is nearly as essential to know the temperature of the cold junction as that of the hot junction since the magnitude of the e.m.f. observed depends upon both temperatures.

A subsequent article will deal with the calibration of base-metal couples and other general pyrometer laboratory data.

The Design and Operation of a Small Kjellin Furnace*

Manufacture of Electric Steel for Stamp-Mill Shoes and Dies on the Witwatersrand, South Africa

BY GEORGE H. STANLEY AND W. BUCHANAN

AS one result of the war and consequent restriction of imports, the mining industry in South Africa found it imperative to utilize to the fullest extent all local resources in plant and material to supply its urgent necessities. Among the latter, obviously, stamp-battery shoes and dies occupy a prominent place, a regular supply to the extent of about 7500 tons annually being essential to the conduct of gold milling. In order to consider the possibility of the manufacture of shoes and dies locally, a committee was appointed in February, 1916, at the instance of the Chemical, Metallurgical and Mining Society of South Africa.

This committee reported that it was of opinion that such manufacture was possible by utilizing existing accumulations of scrap shoes and dies, and strongly recommended that it be undertaken at once in view of increasing shortage and rapid rise in price.

After considering various means of production, such as forging scrap, or melting in coke or gas-fired crucibles, open-hearth furnaces or electric arc furnaces, it appeared that an electric induction furnace of the Kjellin type was most practicable. It was practicable to construct it locally from existing material and of the required capacity. The Victoria Falls and Transvaal Power Company could supply current suitable with some modification for a small furnace, and requiring comparatively inexpensive electrical arrangements. Alternatively, suitable generators, to be motor-driven, were available. This type of furnace does not, however, lend itself to working up miscellaneous scrap in the same way as an arc (or combination induction-resistance) furnace, but this was not contemplated at the immediate time. It requires no electrodes, and could be constructed of locally available materials in from six to eight weeks. Unfortunately, 50-cycle current requires such thin furnace walls that the thermal efficiency is reduced by large radiation, and therefore large furnaces are impossible. Again, the best channel section is narrow and deep, which requires small-sized scrap. It was therefore necessary to install a frequency converter, producing 10 to 15-cycle current.

It is useful to compare the economic efficiency of the induction furnace, including a frequency converter, with that of the arc type plus electrodes. A modern motor-generator of about 200 kw. capacity, converting three-phase, 50-cycle supply into single-phase at low frequency would have a full load efficiency of at least 80 per cent, and since it requires about 800 electrical units to melt one ton of steel, the loss by transformation is 200 units, which at, say 0.6d. (1.2c.) per unit amounts to 10s. (\$2.40) per ton of castings. The consumption of graphite electrodes in furnaces of the Heroult type is at least 15 lb. per ton of steel melted, while in the

Stassano and Rennerfelt types, where the electrodes are not in contact with the metal or slag, it is about 10 lb. The price of graphite electrodes has very considerably advanced, and is now at least 1s. (\$0.24) per lb., so that the cost is 15s. (\$3.60) and 10s. (\$2.40) per ton of steel respectively. The capital cost of induction furnace with converter would be about the same as that of the corresponding arc furnace, with its transformer, and electrode regulating gear.

MATERIAL AVAILABLE

There is at every mine an accumulation of worn and scrapped shoes and dies amounting in the aggregate to several thousands of tons, and on the average about 15 per cent of the new weight of shoes and dies is ultimately discarded as scrap. Much of this has been utilized for such purposes as flooring, but is mostly recoverable if necessary. There is consequently many months' supply for the furnace installed, but it is also possible to utilize other scrap of similar composition and suitable shape, difference in composition being rectified by suitable additions. Manganese is available in high manganese-steel scrap, silicon and carbon in selected cast-iron pig and scrap, carbon as gas-retort carbon and charcoal, while aluminium is stocked in considerable quantity.

Analyses of imported shoes and dies are given in Table I.

TABLE I

| | A. Koppel Die | Orenstein-Koppel Die | Orenstein-Koppel Shoe | Orenstein-Koppel Shoe | Praser & Chalmers Die | Cammell-Laird Die | J. J. Colver Die | J. J. Colver Shoe | Sanderson-Newbolt | |
|-----------------|---------------|----------------------|-----------------------|-----------------------|-----------------------|-------------------|------------------|-------------------|-------------------|-----|
| | | | | | | | | | Shoe | Die |
| Carbon..... | 915 | 815 | 818 | 772 | 865 | 930 | 930 | 700 | 79 | 96 |
| Silicon..... | 250 | 267 | 244 | 206 | 225 | 154 | 211 | 223 | 24 | 17 |
| Manganese..... | 633 | 441 | 385 | 792 | 357 | 672 | 516 | 504 | 59 | 61 |
| Phosphorus..... | 028 | 055 | 014 | 060 | 028 | 033 | 027 | 016 | 014 | 010 |
| Sulphur..... | 060 | 055 | 035 | 056 | 060 | 070 | 038 | 049 | 037 | 021 |

PLANT INSTALLATION

It appeared probable that a furnace of about one ton capacity would be suitable. If this poured a heat of two-thirds of its contents three times per day, two tons of steel would be obtained, equivalent to 12 to 24 shoes and dies, depending on the individual weight. This is roughly 10 per cent of the total requirement and very probably could be considerably increased, possibly even doubled, by quicker working. This, at any rate, would put beyond question the suitability of the product, and enable working costs to be more nearly ascertained.

The furnace itself was constructed as shown in Fig. 1, but with some slight modifications; the cores and yokes being built up of old transformer iron, and the primary winding, consisting of copper cable insulated with asbestos tape, being placed in a three-inch coil

*A combined abstract of two papers: Electric Furnace Manufacture of Shoes and Dies on the Witwatersrand, by Geo. H. Stanley. Jour. Chem. Met. and Min. Soc. of S. Africa, Sept., 1917, and The First Electric Steel-Melting Furnace in South Africa, by W. Buchanan. Jour. S. African Met. of Elec. Eng., Sept., 1917. This part of the papers relates to operation. Features of design will be presented in a second article.

†Details of the design are given later in the article.

space between the core and inner walls of the furnace. Between the inner wall and the coil itself a cylindrical shield of asbestos sheet was placed with the idea of protecting the coil in case of the molten steel breaking through the wall.

Instead of elaborate water-cooling arrangements, air circulation alone is depended on for cooling the coil, a ventilating cowl of asbestos millboard—not shown in the drawing—being placed over the center and connected to a chimney passing through the roof. At first a compressed air jet was used to increase the air velocity, but seemed to have no appreciable effect on cooling and was therefore discarded. This arrangement effects a very considerable simplification of design, and does not seem to be attended with serious drawbacks.

The body of the furnace is built up of special radial and rebated lumps (Fig. 2) tied over all with steel hoops, terminating in screwed ends passing through yokes, so that tightening or loosening could be effected. Any further iron or steel work being very undesirable from the electro-magnetic point of view, the plates between these and the brickwork were of monel metal—another feature believed to be novel—in fact, this alloy is used, replacing iron or steel, wherever desirable and possible in this furnace. To keep the power factor as high as possible, the interior wall was made 8 in. thick (plus, of course, the thickness of the lining), while the outer brickwork has a thickness of 9 in., in each case laid in fireclay. The cover bricks are of radial shape, 2 in. thick, and to prevent breaking or cracking are clamped as shown in Fig. 3 by means of monel metal rod flattened and bent over at the ends, and with screws

put through so that they may be tightened up. A strip between them serves for lifting when required.

In the annular trough formed between the inner and outer walls the working lining of the hearth is placed. One of the initial difficulties was the selection of a suitable material for this lining. Knowing that reasonably pure magnesite occurred in the country, it was originally intended to construct the lining of calcined magnesite, but owing to the difficulty of satisfactorily calcining this material at the temperature under which it is to be used, the first lining was made by ramming ganister, prepared by grinding together pure quartz with a small amount of fireclay, round a sectional wooden template.

OPERATION OF THE PLANT

After removing the template, which left an annular trough 16 in. deep by $5\frac{1}{2}$ in. wide, the lining was allowed to dry naturally overnight and then warmed up by a fire bucket inside the central core space, and finally by burning wood on the hearth. Then, in order to further heat and start the furnace, coals of discarded wire haulage rope—again a novelty—were placed in the hearth, the iron yoke fitted into place and current switched on. However, as the temperature rose, the expansion of the ganister caused it to crack in several places and strip away from the brick of the inner wall. Attempts to repair gave no promise of success, so that the attempt was abandoned. Moreover, the wire rope became badly oxidized, particularly near the tap hole which had not been closed causing it eventually to break circuit. All the inner wall lining was therefore

taken out and replaced by tar-chromite mixture, rammed by hot iron rammers, and a fresh start made with wire rope as before, but with a reducing atmosphere maintained by burning wood in the hearth. The temperature was raised very gradually for nearly three days till the rope began to melt, but with the unexpected result that since melting started at one point only, the melted metal at once dropped to the bottom of the hearth and broke circuit. Attempts to bridge the break by driving in iron bars and adding turnings, etc., were only temporarily successful, and finally fluid cast iron was obtained and poured into the furnace. This restored conductivity, but some of it solidified on top of the wire rope coil, hiding from view the hearth-bottom which, as subsequently appeared, contained a small quantity of fluid metal, while the solid top separated from it was only red hot and heated by radiation from that below. As a result, the temperature of the liquid

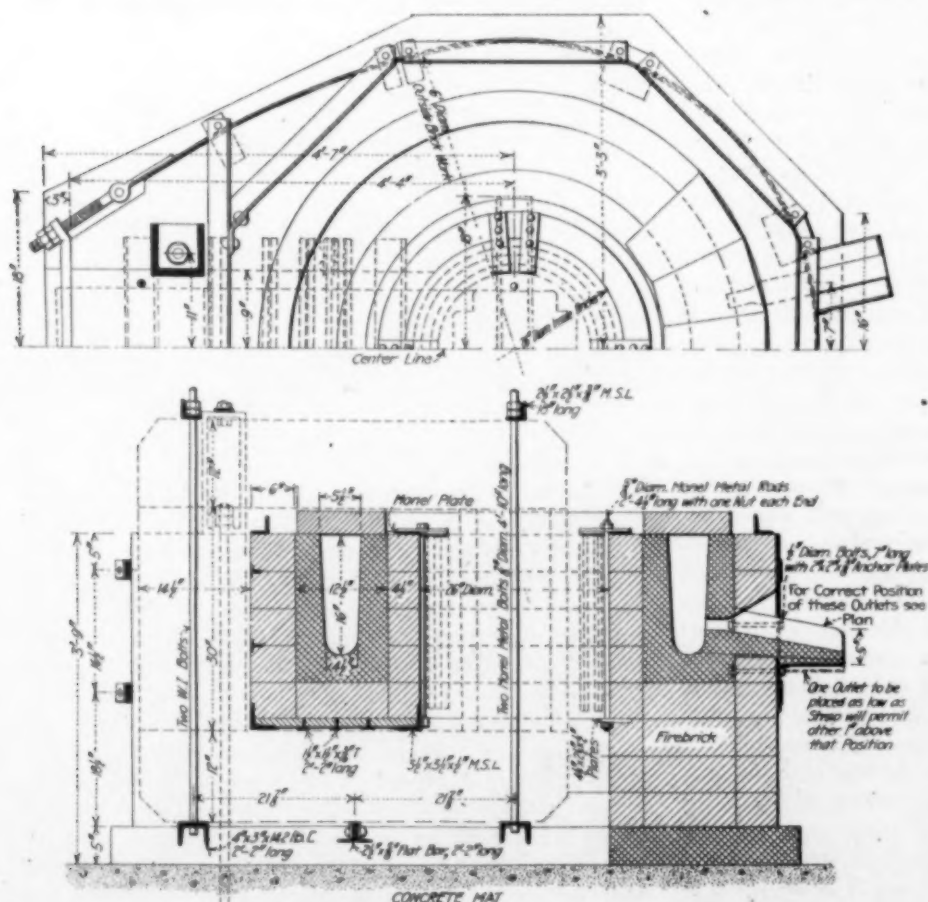


FIG. 1. PLAN AND SECTIONAL ELEVATION OF KJELLIN FURNACE

metal was so increased that the inner chromite lining was melted through and the metal escaped on the floor.

The corrosion had been considerably assisted by chemical action by the carbon and other elements in the iron reacting with the lining, so that the escaping metal was rich in chromium: it seems possible that this idea might be developed as a method for the pro-



FIG. 2. FURNACE BRICK

duction of chrome alloys. Considerable damage was done to the coil and transformer iron, and while this was being repaired the opportunity was taken to obtain some of the magnesite bricks and have them ground down to prepare a fresh lining. This was ultimately made up of a lining of chromite inside the brickwork, faced internally with about 2 in. of tar-magnesite mixture. The heating was started as before with wire rope and molten cast iron, and this time with success. As a result several successful casts were made, though with severe trouble in the management of the tap hole, which broke out several times. Ultimately the furnace was cooled down and the tap-hole re-made entirely, but two days after starting the metal again broke out through the inner wall, damaging the transformer more severely than before, necessitating another long stoppage.

While the repairs were in progress, another difficulty was remedied by modifying the shape of the template to give a hearth $7\frac{1}{2}$ in. x 13 in., and so facilitate the feeding of awkwardly shaped pieces of scrap, though doubtless at the cost of a certain loss of electrical efficiency. It may be mentioned that the slag adhering to the walls reduces the free space for feeding, so that the original width of 5 in. sometimes made feeding extremely difficult.

The new lining, except for about 4 in. of chromite underneath, was rammed entirely of magnesite, which, although known to be impure, was the only supply then available.

After starting up as before the furnace worked relatively smoothly for over a week, and if the output was small it was chiefly due to inexperience; as a matter of fact it only averaged about one cast per day. However, the lining cracked and it was emptied to avoid risk of damaging the transformer.

MAGNESITE LININGS

During this time it has been found that nearly pure magnesite was obtainable, the analyses of four samples showing:

| | | | | |
|---------------------------|------|------|-------|------|
| Silica (SiO_2) | 1.0 | 1.05 | 0.45 | 2.5 |
| Lime (CaO) | 0.08 | 0.20 | trace | 0.10 |

A consignment of this was obtained and calcined, but unfortunately it could only be done at the same time and using the same machinery and kilns as for silica bricks. Consequently considerable contamination occurred, and analyses of different consignments

used for lining showed silica present from 9.7 per cent to 14.0 per cent. However, subsequent relinings were carried out with this material, at first using tar as a binder, but later employing a mixture of clay and boric acid, recommended by Professor Arnold, of Sheffield University, in the proportion of 140 lb. clay, 20 lb. boric acid and 40 lb. water to 2040 lb. of magnesite; but it was found necessary to largely increase the amount of water.

DECARBURIZATION OF THE MELT

Commencing with the employment of a magnesite lining, improvement was rapid, and early this year operations became nearly normal. Early troubles were largely due to alternate heating and cooling of the lining due to labor trouble and other enforced stoppages mentioned, and as these have been eliminated or lessened the frequency of tapping and consequently the output has increased till for some time between 1900 and 2000 lb. of castings have been regularly obtained every eight hours. Now the period is being reduced to six hours. Apart from the material of the lining, the chief difficulty in the early stages was oxidation of the metal and consequent loss of carbon and manganese content, which besides softening it, made it much less fusible. This was due to the rust on the

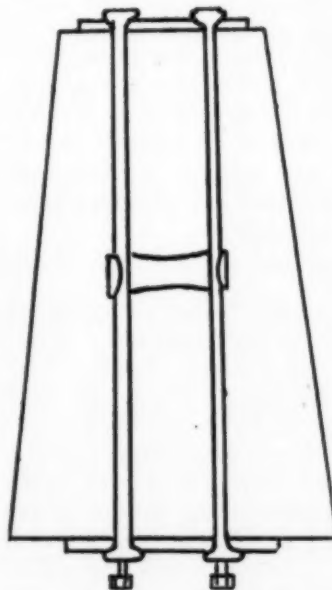


FIG. 3. COVER BRICK

scrap, to scale formed during preheating, and partly also to admission of air to the furnace by defective covers. When, in the early stages, a heat lasted sometimes 24 hours or more, it is not surprising that on occasion all the carbon was lost and dead soft iron was produced. This has been remedied by more rapid working, and by keeping a little charcoal on top of the metal in the furnace. Indeed, the charcoal is so marked in its effect in facilitating the working of the furnace that it is difficult to make the furnace hands

(Cape colored men) use it in sufficient moderation, and for a long time carbon in the steel was nearly always much too high, generally 1.1 per cent to 1.3 per cent. Even now it does not seem advisable to dispense with charcoal entirely, but by exercising proper care, carbon can be kept at about the desired figure, while by stopping the formation of oxide the furnace walls are preserved to a considerable extent from corrosion and their life increased.

The chief furnace trouble at the present is the formation of a "crust" of solid metal more or less completely covering the surface of the molten metal. It is not serious if noticed and dealt with in time, but if allowed to increase by building up and feeding more metal it entails much labor and risk of damage to the walls in detaching it. It does not seem to be of any

assistance to try and make a slag, which indeed is difficult to keep fluid, but sometimes to clean the metal a little fluorspar has been added. Another difficulty, in a recent lining, arose from trying to incline the trough towards the tap-hole. This reduced the cross-section of steel too seriously at the other side, and caused several breakages of circuit after tapping, probably due to the "pinch" effect, so that the tap-hole had to be raised. However, having the hearth level leaves a ring of metal to be removed every time a stationary furnace has to be completely tapped out for relining. In normal operation, lining and working proceed as follows:

RELINING

The old lining having been stripped out immediately after it had cooled sufficiently, the bottom is rammed into place with hot rammers, little by little, and then the template supported in position. This is constructed so that when the ramming is completed the sides can collapse to some extent, thus loosening and facilitating withdrawal. (Lately the bottom has been made rather more V-shaped, so as to keep a continuous starting ring with less weight of metal.) The walls are then rammed in the same manner, and when complete, about twelve hours from the last tapping, the template is withdrawn, the walls completed with a course of flat radial brick, the coil of rope inserted and the yoke replaced. This occupies about three hours more. Current is then switched on, and the furnace is ready for more foundry metal within thirty hours of the last cast. Three ladles, about 500 lb. in all, are then carried across from the foundry and poured in. Generally this solidifies, but in two or three hours is molten again and the feeding of scrap commences.

MELTING

The scrap has previously been heated to redness in the furnace attached to the drying stove, and is transferred by means of tongs to the electric furnace, feeding in several places through spaces left by removing a cover block. This is kept up for two or three hours more, about 2000 lb. of scrap having been charged, after which the metal is left at rest to become hotter and ready for casting, no metal being ordinarily fed within one hour of tapping. At this stage the required amount of pig iron and manganese steel is added. Towards the end most of the slag is skimmed off on the end of flat iron bars, and shortly afterwards the top tap-hole is opened in the usual manner by drilling out its center, which has been plugged by a friable mixture of magnesite, coal dust and clay (the hole itself being lined with the same mixture as the furnace). When the flow of metal has practically ceased it is stopped by placing two or three suitable flat pieces of scrap against the tap-hole inside the furnace. Any metal in the tap-hole is removed while hot. This removal is important, or a break-away may be caused subsequently, and the hole is then made up again. Thereafter charging goes on as before, but with scrap only, except for the additions at the end. The first two or three heats are cast into dies, since the high carbon, sulphur and phosphorus content from the cast iron would lead to breakage of shanks if cast into shoes; thereafter three shoes and five or six dies, or latterly even eight shoes are made per cast.

Cracks and holes appear in due course in the lining, but so far it has not been found possible to patch them successfully. It is often stated in textbooks that this is done, but inquiries have failed to elicit how.

In order to save time in ramming, a pneumatic hammer tool was used recently, and apparently used too well. Nearly 50 per cent increased weight of magnesite was rammed into the lining, and when this was heated up it expanded and cracked badly. This method is still in course of trial, but with a lighter blow, and seems likely to save considerable time, *e.g.*, the interval between the final cast of the old lining and first cast of the new is reduced to about forty hours only.

POURING AND CASTING

A tilting furnace would obviously have prevented much trouble with regard to the tap-hole and tapping, and could doubtless have been made, but in view of the necessity of keeping initial outlay as small as possible the fixed furnace was decided upon. This usually necessitates the intervention of a ladle between the furnace and molds, the metal being tapped into the ladle and poured thence into the molds. Originally, therefore, a ladle and suitable handling gear was installed, the intention being to pour over the lip. However, owing largely perhaps to slow and inexperienced han-

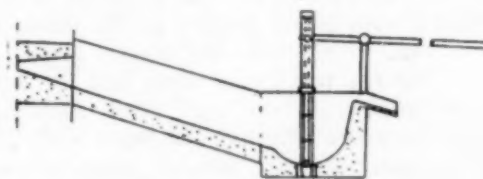


FIG. 4. FORE-HEARTH

dling in the early stages, a very large proportion of the steel solidified in the ladle, forming skulls which constituted so much waste, it being impossible with the available appliances even to break them up for re-melting. In addition, frequent relining entailed much expense and delay. Hand ladles of smaller size were then substituted for a time, three being used in rotation at each cast. This arrangement reduced the loss to some extent, though it was still large, but there was still much lining to be done and, moreover, it was very awkward to operate in the somewhat confined space. Therefore, after some other trials the present method was arrived at.

As shown in the illustration, Fig. 4, the tapping spout is somewhat lengthened, and has attached to its end a box of sheet steel provided with a bottom outlet through a fireclay nozzle, and forming a kind of forehearth. The spout and forehearth are lined as usual and, of course, patched and faced after every cast. The outlet can be closed by means of a fireclay plug, as usual in bottom teeming steel ladles, this plug being carried on a rod actuated by a lever in front, worked by hand. Directly underneath this, and at right angles to the spout, is a line of rails on which a series of flat cars carries the molds, so that they can be moved in turn underneath the nozzle. This has considerably raised the daily output, and on several days over 3 tons of castings have been produced.

It was soon ascertained that it was much easier and simpler to cast onto iron molds (with sand tops);

moreover, the operation requires less skill. Consequently nearly all the production has been made in this manner. But, while overcoming certain troubles, the use of iron molds introduces others, *e.g.*, when, in the case of shoes, the bottom of the mold, forming the shank of the shoe, is worn and rough, it tends to grip the solidified metal and prevent its normal shrinking, thus leading sometimes to cracking at the butt. In use, this crank rapidly results in breakage. This may be overcome in future by molding the shanks only in sand.

The present arrangement is shown (Fig. 5), and it will be seen that there is very little molding work required. To diminish this still further, trials have been made of tops formed of fire brick and of cast iron, but so far the balance of advantage seems to lie with those

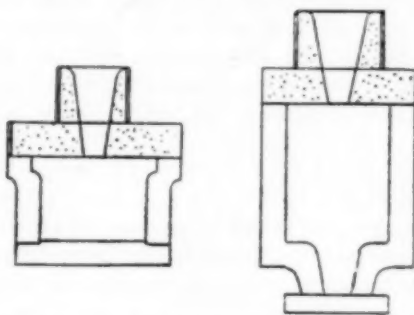


FIG. 5. METAL MOLDS WITH SAND TOPS

of sand. As soon as the mold is filled a little sand is thrown on top and a weight (usually an old shoe) placed on top of that, so that the metal solidifies under a slight pressure. Ultimately the feeder head is knocked off while still hot and the casting is stripped. When cold enough, any fins due to the split molds are trimmed off by hammers, and any irregularity where the head broke off dealt with in the same manner. To obtain sound castings a small amount of aluminium is placed in each mold before casting, this being found more effective than adding it in the furnace.

TEMPERATURES

Attempts were made to ascertain the temperature in the furnace before casting, both by means of a platinum-rhodium thermocouple and Féry radiation pyrometers. Neither method is satisfactory for continuous use; the former is rapidly destroyed and the latter is difficult to use in spite of being mounted directly above the furnace, because the slag chills directly the cover is moved and the metal cools appreciably while slag is being skimmed. The eye, or the old "cutting the rod" test is therefore still depended upon.

In addition to the melting furnace itself, a coal-fired preheating furnace is installed in order to economize electrical power by heating the scrap to redness before it is charged into the electrical furnace, and so arranged that it also heats the drying stove.

THE PRODUCT

It must be confessed that at first the quality of the product was very irregular, a large proportion being honeycombed with blow-holes, and the carbon content varying widely in different casts. With increasing experience this is being regularized, and a more uniform quality turned out.

Carbon is determined in every cast by the Eggertz color test, a sample for the purpose being dipped out from the furnace on the end of a rod, and at intervals a complete analysis is made. Some of these are given below, and it will be seen that carbon is frequently rather high.

| | | | | | | |
|-----------------|------|------|------|-------|-------|------|
| Carbon..... | .64 | 1.18 | 1.12 | .774 | 1.07 | 1.13 |
| Silicon..... | .14 | .357 | .149 | .120 | .186 | .20 |
| Manganese..... | .56 | .600 | .670 | .352 | .52 | .24 |
| Phosphorus..... | .054 | .069 | .043 | .042 | ..... | .021 |
| Sulphur..... | .043 | .050 | .062 | .057 | ..... | .022 |
| Chromium..... | .20 | .14 | .13 | ..... | ..... | .022 |

Under the circumstances it is scarcely surprising that the percentage of shank breakage among shoes has been somewhat high, but of course the reports so far received from the users mainly relate to the earlier product. Investigation showed that high carbon certainly seemed to predispose to breaking, and why this is so can readily be understood. Excess cementite, although very hard, is also very brittle and apt to break under shock; while if the mass is of eutectoid constitution with about 0.9 per cent carbon, no separate cementite exists, and we have a strong homogeneous material. Even up to 1 per cent carbon the amount of free cementite is scarcely appreciable, and it is therefore endeavored to keep the carbon below that point. If a hydraulic press were available to forge the metal somewhat, it would without doubt be fully equal to the imported. At present, by the use of large headers in casting, it is endeavored to keep the metal as sound as possible, but forging is impossible.

Men Wanted for Engineer Replacement Regiment

THE First Replacement Regiment of Engineers was organized at Washington Barracks, D. C., on December 14, 1917. Its specific purpose is to keep all engineering units of the army at full enlistment strength during the period of this war. This regiment has not only the responsibility of finding men to fill up depleted ranks but it must also fit them to step into the work of trained, efficient and disciplined soldiers.

The men are first given infantry drills which gradually gives way to specific technical training. The engineer soldiers must know how to tie all the important kinds of knots and lashings, to build spar and truss bridges, to construct revetments, dig trenches, place wire entanglements, construct machine-gun emplacements, build pontoon bridges and to construct roads. They must also know the methods of demolition, sapping and mining. Specialized training in lithography, zincography, surveying, mapping, photography, carpentry, blacksmithing, electricity and machinery are also given to those qualified for further training in any of these branches.

Male citizens in the United States who are physically fit, and between the ages of 18 and 21, and 31 and 40, are eligible to join the regiment by voluntary enlistment.

Applicants for enlistment should write to the Commanding Officer, 1st Replacement Regiment Engineers, Room 107, Headquarters Building, Post of Washington Barracks, D. C., for application blank and instructions.

Central Stations and the Manufacture of Electrochemical Products*

By C. A. WINDER

TO LOOK at this subject from a central station viewpoint is to consider the economic value of the electrochemist as a customer rather than the engineering questions surrounding the actual use of electric power by him. In the past the central station engineer seems to have taken the attitude along with the apparatus manufacturer that the electrochemist was, strictly speaking, a chemist delving in a field he was perhaps only meagerly acquainted with.

For five years I have been intimately associated with the electrochemists and feel safe in stating that as electrical engineers, especially insofar as their own requirements are concerned, they are as a general rule well qualified; more so in many cases than those with whom they deal. I say this to justify some of the claims they have made which will enter into some of the phases of the situation which I will discuss further on.

But, before considering the economic side of this question, it might be well to look into the power consumption of the various well known electrochemical products, especially those consuming relatively large quantities of power and where the power enters into the chemical reaction rather than furnishing mechanical power. This will determine to a great extent the location of the industry and the price the industry can pay for its power.

This class of electrochemicals will include in the order of their importance, the following: aluminium, ferro-alloys, calcium carbide, artificial abrasives, alkali, chlorine, phosphorus, sodium, carbon disulphide, graphite and similar products. These are all products that are indispensable to the arts and manufactures and at the same time their use has been greatly increased by war demands; demands, by the way, which to a great extent, will not continue after the declaration of peace.

POWER CONSUMPTION FOR VARIOUS PRODUCTS

Aluminium consumes the largest amount of power per pound of finished product (approximately $12\frac{1}{2}$ kilowatt hours) and is perhaps more dependent upon the low cost of power than any of the other above mentioned products. Based upon the calculations of electrochemists in a position to know, it seems possible for aluminium manufacture to exist a thousand miles from the center of gravity of its distribution provided power can be obtained at from \$20 to \$25 a kw.-yr. In this product we have an ideal combination of high consumption of power and low shipping weight.

Next in order considering energy consumption per pound of product is perhaps the artificial abrasives, whose consumption is about half that of aluminium, but the shipping weight of the finished material is quite high. Here we have an industry that cannot stand long freight hauls even with unheard of low prices of power. If the haul of the finished material were two thousand miles, it is doubtful if an artificial abrasive plant could exist where power was free. I do not believe that this industry can stand more than a five hundred mile haul under the prevailing prices of water power.

Calcium carbide, ferro-alloys, sodium, chlorates and phosphorus are in practically the same position as artificial abrasives, all requiring power at the prevailing water-power rates and within close proximity to the center of gravity of their consumption.

Of the ferro-alloys, perhaps ferro-silicon is the most popular just now owing to the high selling price. This price is abnormal, having been brought about by a shortage created by the unprecedented demand for shell steel and armor plate, shell steel requiring some 0.3 per cent silicon, which is a very high percentage compared to the normal run of steel. Furthermore the importation of ferro-silicon from England and Canada has been discontinued and England has even pleaded for some of our ferro-silicon output. Eighty per cent of the ferro-silicon produced in this country comes from the Niagara district, where the power shortage is exceedingly acute and it is practically impossible at the present time to increase this output. Previous to the war, \$70 to \$75 per ton was considered a fair price for this commodity, it having sold as low as \$51, which price incidentally shows no profit whatsoever. Since that time the price has been up above \$200 per ton and now is fluctuating between \$150 and \$175 per ton. This price, of course, is unreasonable, and cannot be expected to remain. Therefore, those who enter into the manufacture of this commodity are treading on rather treacherous ground from an economic standpoint.

From an engineering standpoint, ferro-silicon can be made most economically under normal circumstances in furnaces of about 10,000 horsepower input, and apparently those companies that are now entering this field or contemplate such action are planning on small furnaces. Such engineering cannot withstand the rigors of competition that will follow this war. But, on the other hand, where companies insist on entering this field now to take advantage of the present high prices, limited capital requires the installation of small furnaces.

Another engineering detail in the use of electric power in the manufacture of ferro-silicon has often been overlooked, and it is this particular feature which practically precludes the present day central station from entering this field, though I understand a number of them have been figuring on putting in their off-peak power, particularly their summer valley, into such a load. I am speaking of the question of frequency. As a rule, the central station catering to the lighting load generates at 60 cycles, but 60 cycles almost precludes the operation of a ferro-silicon furnace of any size, the reason being, obviously, that a very poor power factor results from high currents at high frequency. Probably ferro-silicon furnaces of capacities approaching 800 to 1000 horsepower might be built with a result in power factor approaching 90 per cent, relatively larger furnaces would have still lower power factor. This, of course, entails increased cost in the transforming equipment and therefore handicaps you further in the cost of production. Low frequency is a prime requisite to the successful operation of ferro-alloy, calcium carbide and similar furnaces.

United States Government Nitrate plant No. 2 has already encountered a serious difficulty in furnace design for manufacturing carbide, which is a step in the cyanamide process, because of the fact that they have decided on using 60-cycle turbo-generators. How this matter will eventually work out is hard to tell, but ap-

*An address made at the Dayton meeting of the Ohio Electric Light Association. The author represents the General Electric Co. at Niagara Falls.

parently from the engineering done so far, the size of the calcium carbide furnace will have to be materially reduced from the estimated capacity and this, of course, will entail an increased cost of output. Most of the electric furnace products have been developed at Niagara Falls where 25 cycles is the prevailing frequency. Even lower cycles than this are perhaps preferable for electrochemical loads. Consequently the central station at present installed, producing power for domestic and industrial purposes, is handicapped from practically every standpoint.

IMPRACTICABILITY OF OFF-PEAK POWER

If we consider off-peak power for such loads as artificial abrasives, ferro-alloys or calcium carbide, we find that an 80 per cent load factor so greatly increases the overhead costs that the power would have to be obtained without any cost at all to be at all attractive. Daily off-peak power for carborundum, for instance, is absolutely out of the question, as a carborundum furnace operates for thirty-six hour periods. Neither can the graphite furnace be considered for the same reason. Here, of course, the operating periods are considerably longer. Valley power covering a period of eight months is an economic possibility that is not attractive to the average electrochemical industry. There are a few electrochemical markets which are seasonable and whose fluctuations correspond fairly well to the valley of the usual public service company. But to produce the average requirements will entail an investment of 50 per cent in excess of the plant operating on a flat load over a year period and would increase the overhead charges to a point where the proposition is not as a rule attractive.

The smallest user of power per ton output is perhaps the caustic and chlorine industry and is consequently the most affected by long freight hauls. We see as a consequence that caustic and chlorine are manufactured near their markets and comprise one of the few electrochemical industries that the central station may hope to attract. But even here we have the unfortunate situation that confronts all electrochemical industries that depend upon power purchased from a public service corporation, that is, a twenty-four hour load undoubtedly penalized from a bookkeeping standpoint in favor of the domestic consumer. This is known to the caustic manufacturers who in the past have obtained power from power companies whose main output is twenty-four hour power and in consequence the steam plant has not been very successful in attracting the load apparently most suitable to this type of service. Apparently this is a matter for the consideration of the rate-making commissions or commissions approving rate-making in the various states. Naturally, such a situation would have to be brought to the attention of the above mentioned commissions by the central stations themselves.

It is true that under prevailing prices of some electrochemicals there may be some central station whose power could be utilized. The shortage particularly in ferro-silicon may be so acute that the Government will commandeer the power in certain large cities just as they have commandeered the complete output of the power companies at Niagara Falls and Buffalo. This necessitates the closing down of non-essential manufacturing plants with the subsequent damages that always accompany such situation, the central station losing not alone its industrial load but also the load of

those operatives and employees who, through the fact that they have lost their employment, move from the city. Manufacturing plants (industrial) usually require a large number of operatives per horsepower, whereas an electrochemical industry uses a great many horsepower per operative. Where it is possible these manufacturing industries will move to other communities where power is available.

READJUSTMENT WHEN PEACE COMES

When peace comes, as it must in time, be it one year or ten, the electrochemical plants located in cities where the manufacture of their products is uneconomical under normal peace conditions will, of course, fail when competition again becomes keen. It will be those companies located at the present economic positions and possessing water power, which in itself leads to the reduction of costs, whether by virtue of price, quantity or frequency, that will survive this ordeal. The central station may then find itself in the position of having connected load without the ability of their load absorbing its power and it will take a long time to again build up the load to where it was when the war began. Obviously, the only classes of large power users that the modern central station in large cities should solicit are japanning ovens, brass-melting and steel-melting furnaces (where good scrap is available and other conditions correct), as well as hundreds of industrial power-consuming devices now being perfected or which have not as yet become commercially applicable, but will be perfected under the present war stimulus.

It would appear therefore that the various steam-generating companies should use every effort to increase installed capacity of water power for this class of consumer, having in mind the protection of their own interests. Undoubtedly this is true. In the past the steam plant seems to have felt that water power was a competitor of no mean ability, but this is, strictly speaking, not true except in a few minor cases.

In the Niagara district, for instance, the economic situation was vastly improved when the steam plant was installed to take up the daily peaks. We have often been told, but many of us still fail to realize that water power should never be used for loads of short duration. It costs practically no more to generate power for twenty-four hours than for one hour, which is diametrically opposite the steam situation.

INSTALLATION COSTS OF STEAM AND WATER PLANTS

In the case of the steam plant under normal price conditions, installation costs range around \$50 per horsepower with a tendency downward in the future due to new developments in steam-turbine and boiler economics which will be announced to the world after the mad demand for production subsidies. On the other hand, an installed horsepower in water-power plants can be safely stated to be about \$150 under the same economic conditions. But the future instead of reducing the installation costs as in the case of the steam plant holds nothing for it except increased costs. This is due to the conditions to which water-power rights will be subjected by the present Congress should they eventually realize the necessity of legislation of a nature that will permit of the development of some of the fifty-four million available horsepower in our navigable streams. It is a well known fact that the House of

Representatives in Washington feels that no water-power rights should be granted without monetary consideration to the federal government either in the form of a lease or taxes. Added to this, they have, in all the legislation at present considered, insisted that water-power companies develop the navigable streams with a view of bettering navigation conditions on these particular rivers. This entails heavy expense for locks and headwater improvements which undoubtedly will bring the cost of this class of power to about \$200 a horsepower when considered on the basis of prices before the war.

When we consider that we are paying interest on investment for twenty-four hours a day in either steam or water-power developments and our water-power developments cost four times the steam power development, it is easy to see why load factors approaching 100 per cent are essential for water-power plants and that the usual domestic load of four-hour peak tends to the uneconomical use of capital. Considering the steam plant, the major expense is in fuel, which is on a gradually increasing scale owing to the increasing cost of mining coal as well as a slowly but steadily disappearing supply.

When we consider that the year 1917 doubled the installed capacity of steam turbines and that the year 1918, based on orders at hand, will further increase this by 60 per cent of the total installed Jan. 1, 1918, we can readily see what is before us in the way of coal demands which will hardly have a reducing effect on the price of fuel.

Eminent engineers have figured that even with water power at hand, should the load factor be 40 per cent or less, steam power should be used; but should the load factor be 60 per cent and above, water power is the most economical development. The field represented between these two points is subject to local conditions and may or may not be economical water-power or steam-power developments, depending upon other conditions surrounding the particular problem. The only exception to the above would be, of course, a case where the power consumed equalled the total amount of storage available.

Two factors have contributed to the elimination of cheap power; first, the limited development of water power; second, the inability of steam stations to make consistent rates for twenty-four-hour power. This has led to the expatriation of some of our most essential industries. Long ago the only fertilizer industry on this continent, an American company incidentally, went to Canada, where they obtained low power rates. Additions to the Carborundum Company and the Norton Company were built in France and Germany respectively for the same reason. Both of these companies have recently built large plants in Canada. The Union Carbide Company has transferred its carbide production from Niagara Falls, N. Y., to the Canadian side and additions for ferrosilicon in Norway. Lastly, we hear that the Acheson Graphite Company is planning to build at Shawinigan Falls, Que. Thus it is that many of our great industries have gone to other countries in search of cheap power. This may not be serious, but should Canada ever decide to stop exportation of any of these essentials, the United States would find itself in much the same position it was in at the beginning of the war with regard to dyestuffs.

Research Information Committee Formed

THE following statement is authorized by the Council of National Defense:

1. By joint action the Secretaries of War and Navy, with the approval of the Council of National Defense, have authorized and approved the organization, through the National Research Council, of a Research Information Committee in Washington with branch committees in Paris and London, which are intended to work in close co-operation with the officers of the Military and Naval Intelligence, and whose function shall be the securing, classifying and disseminating of scientific, technical and industrial research information, especially relating to war problems, and the interchange of such information between the Allies in Europe and the United States.

The chief functions of the foreign committees thus organized are intended to be as follows:

(a) The development of contact with all important research laboratories or agencies, governmental or private; the compilation of problems and subjects under investigation, and the collection and compilation of the results attained.

(b) The classification, organization and preparation of such information for transmission to the Research Information Committee in Washington.

(c) The maintenance of continuous contact with the work of the offices and military and naval attachés in order that all duplication of work or crossing of effort may be avoided, with the consequent waste of time and energy and the confusion from duplicated effort.

(d) To serve as an immediate auxiliary to the offices of the military and naval attachés in the collection, analysis and compilation of scientific, technical and industrial research information.

(e) To serve as an agency at the immediate service of the commander in chief of the military or naval forces in Europe for the collection and analysis of scientific and technical research information, and as an auxiliary to such direct military and naval agencies as may be in use for the purpose.

(f) To serve as centers of distribution to the American Expeditionary Forces in France and to the American naval forces in European waters of scientific and technical research information, originating in the United States and transmitted through the Research Information Committee in Washington.

(g) To serve as centers of distribution to our allies in Europe of scientific, technical and industrial research information originating in the United States and transmitted through the Research Information Committee in Washington.

(h) The maintenance of the necessary contact between the offices in Paris and London in order that provision may be made for the direct and prompt interchange of scientific and technical information.

(i) To aid research workers or collectors of scientific, technical and industrial information from the United States, when properly accredited from the Research Information Committee in Washington.

The headquarters of the Research Information Committee in Washington is in the offices of the National Research Council, 1023 Sixteenth Street; the branch committees are located at the American Embassies in London and Paris.

The Physical Properties of Copper and the Factors by Which They Are Affected—IV.

BY PAUL D. MERICA

Division of Metallurgy, U. S. Bureau of Standards

(Concluded from page 307)

Impurities in Copper; Effect on Physical Properties

OXYGEN

THE constitution of the alloys of copper and oxygen (Cu_2O) shows that oxygen is present in copper as Cu_2O , not dissolved appreciably by the copper (223). There seem to be no published records of test results showing the effect of oxygen on copper free (in the commercial sense) from other impurities. It is, of course, well known that in melting copper it must be brought to pitch in order that it may be cast free from blowholes and possess the best mechanical and "working" properties. If under pitch the presence of blowholes will cause seams in the metal which may open up in drawing; if underpoled the excess oxygen may cause cracking during cold-rolling, and if the oxygen is in amounts as great as the eutectic composition it may also be hot-short.

Hampe (253) found that Cu_2O had no effect on the strength or malleability of pure copper until 0.45 per cent was reached, when a very slight diminution of tenacity was recorded. Ductility in the cold was not affected until 0.9 per cent was reached. Beyond 0.9 per cent the quality of the copper suffered more and more as the proportion of Cu_2O was increased.

Johnson has given some results of tests of oxygen bearing arsenical copper; see Table IX.

The influence of oxygen on copper is chiefly interesting in conjunction with that of other impurities, notably bismuth, antimony, arsenic and lead. It diminishes the embrittling effect of bismuth (Johnson) and lead; this is probably due to two facts: (1) That in the presence of oxygen an oxide of either of these metals is formed which melts at a higher temperature than the metal, and (2) that this oxide is distributed as fine globules instead of thin plates as is the metal.

Greaves (252) has studied the effect of oxygen in copper containing arsenic and antimony, studying the cold-rolling and drawing properties, hardness and microstructure. His conclusions relative to cold-rolling (strips were cold-rolled with annealing from 0.35 to 0.02 in. in thickness) are:

"As the amount of arsenic increases up to 0.5 per cent the metal may take up more oxygen without suffering deterioration in its capacity for rolling. This quantity of oxygen rises from about 0.05 per cent to 0.2 per cent as the arsenic increases from 0 to 0.2 per cent, then more slowly to about 0.28 per cent as the arsenic rises to 0.5 per cent. . . . When less than 0.3 per cent of O₂ is present, a metal which will roll perfectly is obtained before the arsenic reaches 0.5 per cent.

"In a similar way antimony up to 0.4 per cent reduces the cold-shortness of pure 'dry' copper."

His conclusions relative to wire-drawing tests are that the conditions obtaining are entirely similar to those in rolling copper.

Baucke (Tables IV and X) has some results on the toughness of cast and forged alloys with varying percentages of oxygen.

PHOSPHORUS

The diagram for alloys of copper and phosphorus has been partly established by Heyn and Bauer (224). Phosphorus in the form of Cu_3P is dissolved in copper to the extent of 0.175 per cent. Phosphorus in these small amounts hardens copper, as can be seen from Table VIII of Muenker's (273) results.

SILICON

The alloys of silicon and copper have been studied by Rudolphi (226) and Guertler (227).

Copper with small amounts of silicon (0.02 to 0.10 per cent) is used abroad for telephone wire, electric cables, etc. The electrical conductivity is decreased by about 2 per cent by addition of 0.02 to 0.05 per cent silicon (Guillet).

Apparently in small amounts it does not harden copper appreciably (Vickers 281); the copper cast using silicon as a deoxidizer is often called silicon bronze, although it contains practically no silicon.

SILVER

The constitution of the silver-copper alloys has been studied by Heycock and Neville (228), Lepkowski (230), and others. Copper takes up about 3 per cent of silver in solid solution.

Johnson (261) studied the effect of additions of silver to tough-pitch copper and concludes that up to about 0.2 per cent the tensile strength is increased by about 3 to 5 per cent, the elongation decreased by 10 to 15 per cent, and that "the effect of silver in the proportions ordinarily found . . . is beneficial on the whole as regards mechanical properties and negligible as regards hot-working properties"; see Table IX.

SULPHUR

The constitution of the copper-sulphur alloys has been studied by Heyn and Bauer (231).

The amount of sulphur as Cu_2S taken up by the copper in solid solution is extremely small (<0.1 per cent).

Opinion seems to be agreed that as little as 0.1 per cent sulphur in copper renders it hot-short (276). No investigation has been made of the effect of sulphur on the mechanical properties at ordinary temperatures.

TIN

The copper-tin equilibrium diagram has been worked out by Heycock and Neville (233), Shepherd and Blough (234), and others. Copper dissolves about 11 per cent of tin, and within these limits it is hardened by the tin addition.

Muenker (273) gives results of mechanical tests on copper-tin alloys; see Table VIII. Baucke finds that tin in small amounts increases the toughness of copper; see Table X. The alloys of tin and copper are called bronzes, and are generally used of compositions from 0 to 25 per cent tin.

TITANIUM

The equilibrium of the alloys of titanium and copper has been studied by Bense (235) and Rossi (236). Copper dissolves up to 0.32 per cent of titanium. In small proportions this metal raises the tensile strength and lowers the ductility.

TABLE IX—EFFECTS OF BISMUTH, SILVER, AND ALUMINIUM ON THE PROPERTIES OF ARSENICAL "TOUGH-PITCH" COPPER (JOHNSON, 261)

Ingots were made of cathode copper, arsenic and impurity, poled to pitch and cast as $1\frac{1}{4} \times 1\frac{1}{4} \times 6$ in. ingots, rolled at bright red heat in 8 passes to $\frac{1}{4}$ -in. rod and quenched.
Some specimens were hammered out flat to $\frac{1}{4}$ in. thickness cold, then passed through cold rolls set at $\frac{1}{4}$ in. The specimens were then annealed at dull red heat for $\frac{1}{2}$ hour and quenched in water.

| Mark | CHEMICAL COMPOSITION | | | Appearance of Ingot | HOT-ROLLED RODS | | | RODS COLD-ROLLED AND ANNEALED | | Cold Bend Test | Cold Mal- leability. Reduction in Thickness Under Hammer ¹ | Description | Order of hot Mal- leability ² |
|----------------|----------------------|--------------------------------|----------------------|---------------------|---|--|--|--|--|----------------|---|------------------|--|
| | Oxygen, per Cent | Added Impurity, per Cent | Arsenic, per Cent | | Alterations to Rupture, Arnold Test | Tensile Strength, 1000 Lb./ Sq. In. | Elonga- tion in 3 In., per Cent | Tensile Strength, 1000 Lb./ Sq. In. | Elonga- tion in 3 In., per Cent | | | | |
| R | 0.089 | Nil | Nil | Level | 164 | 33.5 | 39 | ..... | ..... | 180° U | 89 | Slight cracks | 1 |
| E | 0.066 | ..... | 0.344 | Level | 190 | 35.1 | 41 | ..... | ..... | 180° U | 91 | No cracks | 2 |
| EE | 0.060 | ..... | 0.410 | Level | 177 | 35.3 | 51 | 32.3 | 35 | 180° U | 91 | Incipient cracks | 2 |
| V ¹ | 0.052 | ..... | 0.361 | Level | 190 | 35.3 | 38 | ..... | ..... | 180° U | 91 | No cracks | 2 |
| V | 0.182 | ..... | 0.300 | Elevation | 122 | 32.6 | 34 | ..... | ..... | 135° b | 67 | Incipient split | 2 |
| U | 0.091 | ..... | 0.383 | Depression | 152 | 35.2 | 47 | ..... | ..... | 180° U | 89 | Incipient crack | 2 |
| W | 0.162 | ..... | 0.427 | Depression | 160 | 34.2 | 45 | ..... | ..... | 180° U | 79 | Incipient crack | 2 |
| F ¹ | 0.056 | 0.042 Ag | 0.300 | Level | 180 | 35.3 | 48 | 32.7 | 36 | 180° U | 91 | No cracks | 2 |
| F | 0.075 | 0.087 Ag | 0.363 | Depression | 161 | 36.0 | 33 | ..... | ..... | 180° U | 91 | No cracks | 2 |
| FF | 0.063 | 0.094 Ag | 0.417 | Level | 187 | 35.6 | 43 | 34.0 | 43 | 180° U | 86 | Slight crack | 2 |
| G | 0.200 | 0.185 Ag | 0.373 | Depression | 170 | 36.0 | 39 | ..... | ..... | 45° b | 81 | Incipient crack | 2 |
| GG | 0.058 | 0.175 Ag | 0.453 | Level | 174 | 37.9 | 39 | 34.4 | 46 | 180° U | 90 | No cracks | 2 |
| H | 0.095 | 0.292 Ag | 0.305 | Depression | 174 | 36.4 | 41 | ..... | ..... | 180° U | 88 | Incipient crack | 3 |
| HH | 0.048 | 0.292 Ag | 0.423 | Level | 180 | 36.8 | 47 | 33.0 | 37 | 180° U | 83 | Incipient crack | 3 |
| K 1 | 0.079 | 0.052 Bi | 0.366 | ? | 186 | 33.8 | 50 | ..... | ..... | 180° U | 89 | No cracks | 5 |
| KK 1 | 0.055 | 0.051 Bi | 0.420 | Level | 201 | 35.2 | 44 | 33.8 | 42 | 180° U | 89 | Incipient cracks | 5-6 |
| K 2 | 0.084 | 0.074 Bi | 0.464 | Depression | 172 | 35.3 | 40 | ..... | ..... | 180° U | 85 | Incipient cracks | 5-6 |
| KK 2 | 0.068 | 0.073 Bi | 0.403 | Level | 186 | 35.4 | 46 | 32.7 | 40 | 180° U | 89 | Incipient cracks | 6 |
| K 3 | 0.155 | 0.094 Bi | 0.355 | Depression | 178 | 33.8 | 37 | ..... | ..... | 180° U | 79 | Slight crack | 5 |
| KK 3 | 0.084 | 0.097 Bi | 0.390 | Level | 178 | 36.0 | 48 | 33.1 | 33 | 180° U | 83 | Incipient crack | 7 |
| K 4 | 0.127 | 0.122 Bi | 0.400 | Depression | 158 | 35.2 | 45 | ..... | ..... | 180° U | 87 | Slight crack | 7 |
| KK 4 | 0.073 | 0.124 Bi | 0.468 | Level | 164 | 36.2 | 42 | 33.2 | 35 | 180° U | 90 | No cracks | 8 |
| X | 0.026 | 0.014 Al | 0.526 | Level | 199 | 34.4 | 44 | ..... | ..... | 180° U | 92 | Uncracked | 2 |
| Z | Nil | 0.329 Al | 0.260 | Depression | 189 | 35.5 | 43 | ..... | ..... | 180° U | 79 | Deep splits | 8 |

¹Test piece, 0.75x0.375", placed under hammer and subjected to light blows until cracks appear.

²Material falling in classes 1-4 may be rolled at a bright red heat. (The point which determines the classifying of metal between 1 and 4 is the comparative susceptibility to cracking during rolling. Class 5 may be regarded as the critical stage between material fit for rolling at a bright red and material unfit for such treatment, material of this class (5) would better be rolled at a slightly lower temperature. Material in a lower class can be considered unfit for hot rolling.)

U=unbroken, b=broken.

ZINC

The zinc-copper equilibrium diagram has been studied by Roberts-Austen (239), Shepherd (240), Tafel (241), and others.

Zinc is dissolved in copper to the extent of about 35 per cent. It hardens copper and first increases, then diminishes its ductility. Curves, Fig. 24, by Webster

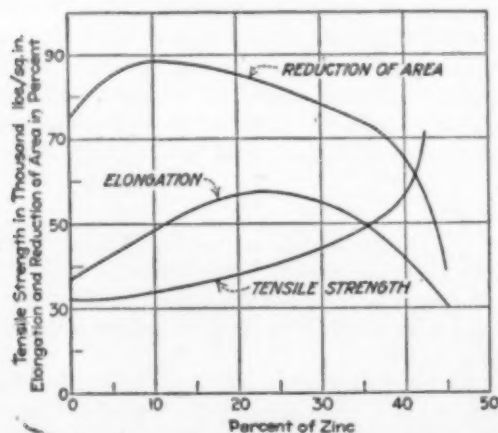


FIG. 24. MECHANICAL PROPERTIES OF ROLLED AND ANNEALED COPPER-ZINC ALLOYS (WEBSTER)

(282) show the mechanical properties of rolled and annealed copper-zinc alloys; i.e., the brasses, made of pure materials.

Baucke finds that zinc in small amounts increases the toughness of copper; see Table X.

GASES IN COPPER

It is generally held that the solubility of gases in solid copper is quite small; in fact, it is to this prop-

TABLE X—BAUCKE (246). EFFECT OF IMPURITIES ON SPECIFIC IMPACT WORK (FRÉMONT TEST) OF COPPER

Specimens 10x10 mm. in section, with 3-mm. saw cut; specimens prepared by casting a 6x6x6 cube and forging hot or cold followed by annealing to 10x10 section. Original electrolytic copper from which samples were prepared analyzed:

Copper, 99.884
Lead, 0.008
Iron, 0.018
Oxygen, 0.080

| Composition, per Cent | Preparation of Sample | Specific Impact Work Necessary for Fracture, Kgm. ¹ |
|--|--------------------------------------|--|
| Electrolytic copper | Forged hot | 14, 13 |
| Bismuth 0.025 | Forged samples | 4 (6 - 2.5) |
| Arsenic 0.53 0.61 | Cold-forged, annealed Hot-forged | 14.8 (25 - 5) 16.8 (21 - 11) |
| Antimony 0.37 0.56 | | 11.5 (13 - 8) 4.8 (6 - 3) |
| Nickel 0.17 0.31 1.52 | Hot-forged Hot-forged | 20.1 (29 - 15.5) 22.8 (26.5 - 21) 28.6 (34 - 24) |
| Tin 1.20 1.92 | | 28.4 (29 - 27) 26.7 (33 - 24) |
| Zinc 0.68 1.42 | | 18.1 (29 - 14) 29.6 (31 - 28) |
| Aluminum 0.02 0.02 | (Oxygen-free) (Cu ₂ O) | 26.0 (27 - 24) 5.2 (9.5 - 2) |
| Manganese 0.03 0.53 1.09 | | 30.2 (33 - 27) 30.6 (32 - 30) 34.0 (35 - 33) |
| Oxygen 0.06 0.10 0.12 0.18 0.51 | | 11, 15 10.8, 12.2 8.3 6.0 9.0 |

¹Baucke gives S. I. W. in kilos, but it is assumed that he means kilograms meters.

erty that the "spewing" upon solidification of overpoled copper is due. The molten copper absorbs gas which is given up upon solidification.

Sieverts (284, 285) has determined the solubilities of H_2 and SO_2 in copper. He finds that 100 grams of copper will absorb the following amounts of gas:

TABLE XI—ABSORPTION OF GAS BY COPPER

| Temperature, Deg. C. | H_2 , Solubility in Mg. per 100 Grams | SO_2 , Solubility in Mg. per 100 Grams |
|----------------------|---|--|
| 1400 | 1.2 | |
| 1330 | ..... | 706 |
| 1220 | ..... | 596 |
| 1120 | ..... | 448 |
| 1084 (liquid) | 0.6 | ..... |
| 1084 (solid) | 0.2 | ..... |
| 400 | 0.006 | ..... |

N_2 , CO , and CO_2 are not appreciably soluble in solid copper. He finds that for a constant temperature the solubility is proportional to the square root of the pressure of the gas.

Both silver and gold diminish the solubility of SO_2 in molten copper, the former much more markedly than the latter.

Sieverts (284) concludes that dissolved hydrogen has no appreciable effect on the electrical conductivity up to 870 deg. C., but that SO_2 increases the resistivity (part of this change may have been due to interaction with the porcelain containing tubes).

"Diseases" of Copper

Copper is, relatively speaking, insensitive to thermal variations in conditions and operations of manufacture. After annealing or after forging operations at a bright red heat (900 deg. C.) it may be slowly cooled or quenched in water, the latter method conferring, according to some, even greater ductility and toughness than the slow cooling.

It is possible, however, to overheat and to burn copper. Heyn (289) has shown that maximum toughness (repeated bend test) is obtained by annealing at 500 deg. C., the time of annealing being without effect. Samples of copper which gave $6\frac{3}{4}$ 90-deg. bends upon such annealing gave only four when annealed for 90 minutes at 1050 deg. C.

Baucke (287) has shown that heating to 700 deg. C. has practically no effect on the toughness as indicated by the Frémont test; in fact, heating in air or CO , at 1055 deg. C. for 15 minutes produced only a slight decrease of the specific impact work necessary to fracture from 77 to 101 ft.-lb. (11.6 to 15.1 kgm.).

Copper should be worked at about 900 deg. C. and not above 1000 deg. C., according to Johnson (290). If heated to and worked at temperatures in the neighborhood of the eutectic melting temperature the copper may be burnt, pits form and grain boundaries become oxidized.

When copper is heated to 800 deg. C. and above in an atmosphere of reducing gases, CO , H , etc., the gases permeate into the copper and reduce the Cu_2O ; water is formed, as steam under pressure, and produces fine cracks throughout the copper, which is described as "gassed." Such copper is, of course, weak and brittle. A photomicrograph, Fig. X, shows such cracks near the brazed seam of a failed copper bend steam pipe. The brazing operation was improperly conducted, a reducing flame having been played on the copper with

the result that cracks were formed near the surface, leading later to failure. Baucke (287) has reduced the toughness of copper as shown by the Frémont test from a specific impact work necessary to fracture of 94 to 101 ft.-lb. (13 to 14 kgm.) to 14.5 ft.-lb. (2 kgm.) by heating the sample for two hours at 800 deg. C. in hydrogen gas.

Matthews and Thalheimer (191) have carried out the most extensive tests to determine the actual effect of annealing in a reducing atmosphere on the strength and ductility of copper. They used coal gas and annealed for 40 minutes strips of from 0.064 to 0.067 in. in thickness at 600 deg., 800 deg. and 1000 deg. C.

Their average results are given in Table XII.

TABLE XII—EFFECT OF ANNEALING IN COAL GAS ON MECHANICAL PROPERTIES OF COPPER

| Time of annealing, 40 minutes. | | | |
|--------------------------------|-------------------------------|-----------------------------|----------------------|
| | Tensile Strength, Lb./Sq. In. | Reduction of Area, per Cent | Elongation, per Cent |
| Electrolytic copper | 33,000 | 46 | 54 |
| 600 deg. C. | 29,000 | .. | 22 |
| 800 deg. C. | 19,000 | 12 | 11 |
| 1000 deg. C. | 21,000 | 12 | 11 |
| Mohawk copper | 33,000 | 49 | 55 |
| 600 deg. C. | 30,000 | .. | 27 |
| 800 deg. C. | 18,000 | .. | 8 |
| 1000 deg. C. | 21,000 | 15-18 | 16 |
| Copper Range copper | 33,000 | 50 | 57 |
| 600 deg. C. | 31,000 | 39 | 41 |
| 800 deg. C. | 21,000 | 12 | 11 |
| 1000 deg. C. | 22,000 | 16 | 16 |

The Copper Range copper, containing 0.296 per cent arsenic, undoubtedly resists the action of reducing gases better than do the purer varieties. This is also shown by experiments by Bengough and Hill (247.)

CORROSION OF COPPER

Copper is exposed to corrosion by water, air, steam, etc., in a variety of commercial forms, pipe, steam fittings, roofing, etc., so that the question of the corrosion of copper under such conditions is an important one. Practically no systematic investigation has been made, however, of the rate of corrosion of different samples of copper under these various conditions.

Carpenter (296) exposed sheets of aluminium, copper, iron and other metals to corrosion on the roof of an office building, in a railway tunnel, and in smokestack plates, and observed the rate of corrosion expressed in loss of thickness per surface inch per year. His results follow:

TABLE XIII—CORROSION LOSS

| | On Office Building, Inches | In Railway Tunnel, Inches | In Smokestack Plates, Inches |
|-------------------|----------------------------|---------------------------|------------------------------|
| Copper (plain) .. | 0.0000 | 0.004 | 0.014 |
| Aluminium | 0.0011 | 0.013 | ..... |
| Iron | 0.001 to 0.004 | 0.15 | 0.018 |
| Steel ..... | ..... | 0.12 | 0.020 |

The copper samples tested were from 99.53 to 99.76 per cent pure. The corrosion was quite uniform in the case of the copper and is seen to be less than that of the other materials.

Corrosion of copper may be quite uniform, a covering and protecting layer of oxide or green basic carbonate or, in marine atmospheres, of oxychloride, being formed. Often, however, the attack is quite local, with formation of pits and furrows. Such pits are mentioned by Corner (297), Merica (299), and others; they are to be attributed to local electrolytic action

caused by the presence near the pit of a substance electronegative to the copper. It is probable that copper oxide and even some of the basic oxidation products of copper may serve as such electronegative "poles."

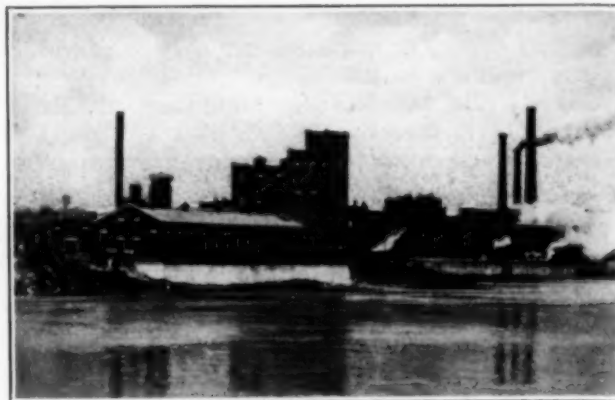
It has been shown by Rhead also (301) that hard copper is more readily corrodible than soft copper, the rate of corrosion of the former having been 0 to 500 per cent greater than that of the latter in his experiments. Eastick (298) also holds that the presence of hard and soft areas in copper are often responsible for local corrosion.

Alcohol from Sulphite-Pulp Waste Liquor

Plant of the West Virginia Pulp & Paper Co. at Mechanicville, N. Y.

BY ELLWOOD HENDRICK

"THERE'S a good deal o' miscellaneous eatin' to a sheep," said a Scotchman, and anyone who has ever tasted haggis will confirm the statement. Likewise any chemist who has had to do with sulphite-pulp waste liquor is apt to find a similar disposition within his soul and to declare that there is a good deal of miscellaneous chemistry in it. The liquor contains from 8 per cent to 10 per cent of dry residue, which includes the lignin, with all that the word implies. Less than one and a half per cent of the dry residue is inorganic. In varying quantities there is SO_2 , both free and combined, sulphuric acid and about three-quarters of 1 per cent of lime. The sugar content varies from a maximum of 3 per cent to something pretty close to zero as



WEST VIRGINIA PULP AND PAPER MILL,
MECHANICVILLE, N. Y.

the minimum. One per cent of alcohol from the liquor is a very high yield, even in Sweden. With good practice about two-thirds of the sugar is fermentable.

In 1913 the West Virginia Pulp & Paper Company put up the first plant in the United States at Mechanicville, N. Y., to make ethyl alcohol from this material. Operations began in March, 1914. Counting all the costs, it has not been a profitable undertaking. But where should we be if there were nobody to try things out? The feeble of will are discouraged by unsuccessful experiments, and such men lead only at industrial funerals. The real leaders in industry, on the other hand, have the virtue of perseverance along with the quality of sportsmanship, and often, indeed, they can see romance in a scrap-heap that wrings only tears of gloom from their ungifted fellows.

The alcohol plant was built to treat 100,000 gallons of waste liquor a day, which at that time was the regular product of the establishment at Mechanicville. They have been producing 500 gallons of alcohol per day. This is now running somewhat higher owing to changes in methods.

Whether any of the sugar found in the liquor is that which was formed of water and CO_2 by the catalytic action of chlorophyll in the green leaves of the trees while still growing seems still open to question, although it is hardly possible that more than a very small portion of it, if any, can come from this source. Dr. Erik Haeggglund, in

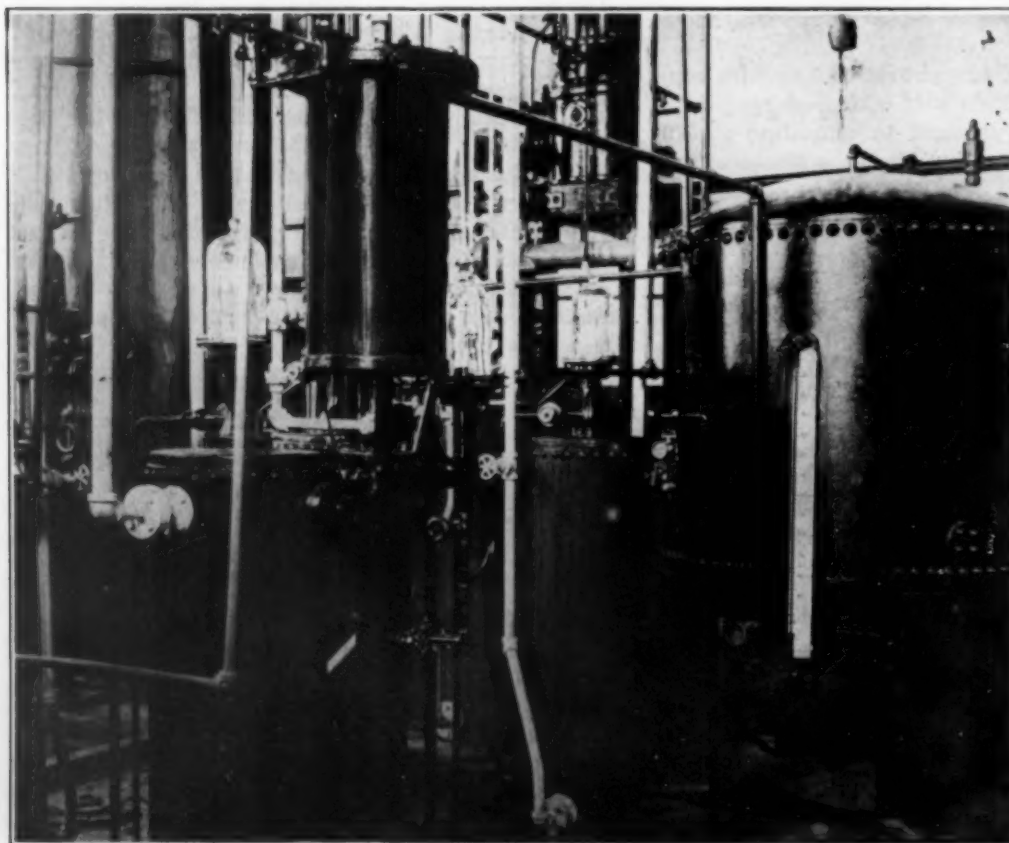


FIG. 1. ALCOHOL STILL, W. VA. PULP & PAPER CO., MECHANICVILLE, N. Y.

an interesting series of articles,¹ claims that wet wood produces more sugar than that which is dry. This has not been confirmed at Mechanicville. He also expresses the opinion that none of the sugar present has its origin in cellulose, although he says that Dr. Eckstrom, under whose patents these works are operated, holds the opposite view. The impression prevails also that a good part of the sugar is the product of lignin; from all of which we may gather that the chemical history of the sugar in sulphite waste liquors is still more or less guessed at.

The presence of fermentable sugars is in part dependent upon the cooking. A high content of free SO_2 tends to increase the sugar in the waste liquor and to shorten the time of the cook. There are also other reasons for the disposition of pulp makers to increase the free SO_2 in their digesters. So we may set down as a rule that if the free SO_2 in the digesters is inadequate, the sugar will be deficient; and we even venture the assertion that the more free SO_2 there is in the digesters, the more sugar will be produced. But we must immediately qualify this statement, because as soon as the SO_2 concentration gets too high, the sugars are decomposed. Indeed, an excess of free SO_2 will destroy the sugar before the cook is completed. Fermentable sugars are more easily decomposed in this manner than the pentoses (xylose). Too high a temperature alone will also destroy the sugar in the digesters. The good feature of the situation is that with the speed of the cook increased by the SO_2 concentration, it is possible so to regulate the process that it is brought to a conclusion at the point where the maximum sugar is obtained. It is not difficult to do this on the one hand, and it is not a rule-of-thumb operation on the other.

From the pulp mill the liquor is run into a great tank. Then the first step in making alcohol from it is to pump it into the neutralizing towers, which have a working capacity of about 40,000 gallons each. This is also a process involving a lot of miscellaneous chemistry. One one-hundredth of 1 per cent of sulphurous acid will kill yeast in 24 hours. Sugar is broken up as soon as a state of alkalinity is reached. Lime in solution is carried over and clogs the still columns and dephlegmator tubes; it takes an interminable time to settle, and fermentation demands a clear liquid.

¹Published in *Paper*, December, 1917, and *January*, 1918. Vol. XXI, Nos. 16 to 20.

Calcium carbonate produces gypsum, which may leave a clear solution at first, but as it approaches the boiling point a precipitation of extremely small crystals of gypsum takes place. The usual method is to split the troubles by adding the proper quantity of slaked lime at first and half an hour afterwards some pulverized limestone. At Mechanicville lime sludge from the soda pulp mill is employed, which is acknowledged to be the best practice, provided the soda pulp mill is handy.

When the liquor and lime sludge are led into the neutralizing tanks, agitation is accomplished by the introduction of compressed air at the bottom. This is continued for three hours, after which it is allowed to settle for 11 hours; then the clarified liquor is decanted and the sludge, which is now gypsum, is discarded. But the liquor is not yet clear enough, lime and gypsum are still in suspension, and it is still warm. It is therefore run into so-called neutral lye bins which are long and shallow, where it settles for from 10 to 12 hours more. It is now clear enough to go on with the fermentation, but it is not yet cool enough, so from the neutral lye bins it is pumped into a very simple cooling tower. This is constructed with a receiving tank having a perforated bottom at the top of the tower. From the perforated bottom there extend downward for several feet a series of board partitions, several inches apart, which serve as a trickling device. From these the liquor falls down in the form of a very lively rain. Halfway down the drops meet a blast of air from a blower, which blows the liquor pretty well over to one side of the tower, but it is all collected at the bottom in another tank. It is a remarkably effective cooling system.

From the tank at the bottom of the tower the liquor flows by gravity into the fermenting vats. These are

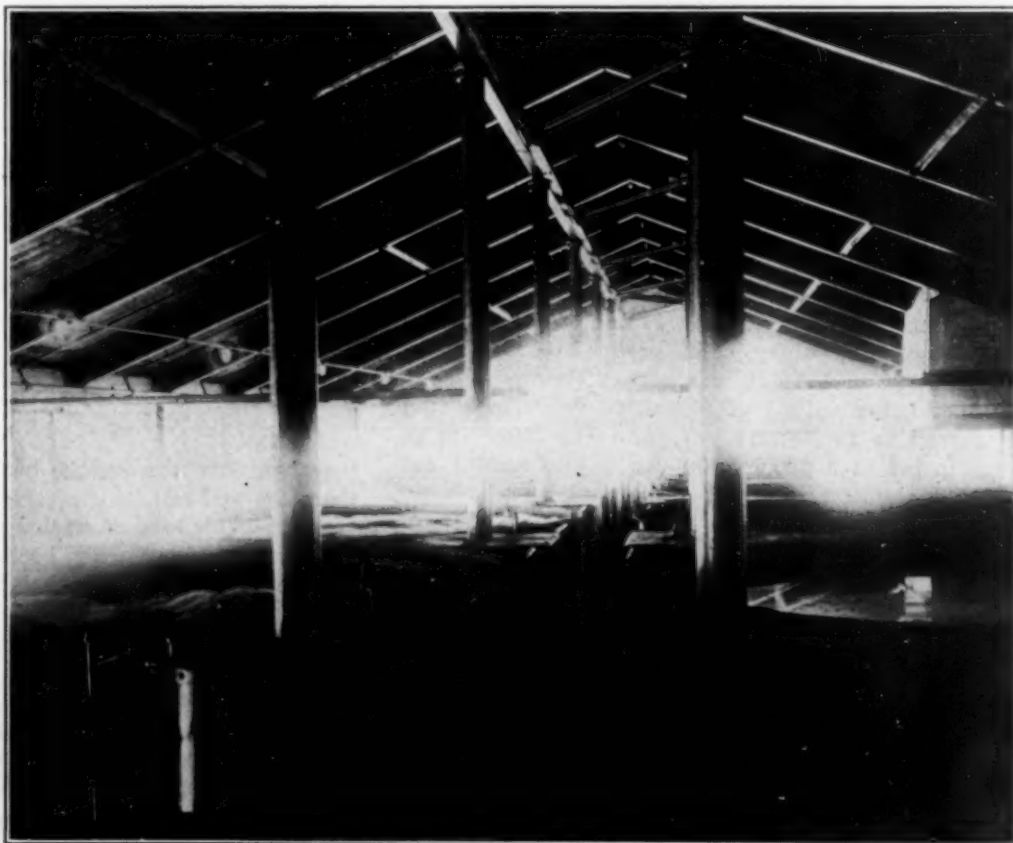


FIG. 2. FERMENTING VATS, W. VA. PULP & PAPER CO., MECHANICVILLE, N. Y.

of concrete, circular in form and hold about 35,000 gallons each. The yeast and its proper food is already in the fermenting vats into which the cooled liquor now enters through three vents, so arranged as to give a circular motion to the entering liquor and thoroughly mixing it with the yeast. By means of this agitation the fermenting begins within about twelve hours. If the liquor is poured into the vat at the top without other agitation, it does not begin to ferment until about 48 hours has elapsed.

The yeast was brought over from Sweden by Dr. Eckstrom, who designed the plant. Dr. Haeggglund found types XII and M, distillery yeasts of the Berlin Institute of Fermentation Industry, to be peculiarly suitable. Dr. Drewsen of the West Virginia Pulp & Paper Company made certain researches in the matter and found other yeasts also available. Dr. Eckstrom's yeast, however, is still in use, although, owing to the nature of the liquor and its chemical miscellaneousness, the spent yeast is not reclaimed. To support its growth, spent brewers' yeast is submitted to "autodigestion" by heating it to 40 to 50 deg. C. under pressure. The protein substances are thus digested by the enzyme endotryptose with the consequent formation of amides.

Dr. Haeggglund reports that Sweden produces 660,000 gallons of alcohol annually by this method. He also computes that inasmuch as Germany produces 550,000 metric tons of pulp per year, they must be making 5,284,000 gallons of alcohol out of their waste liquors. But statistics based upon what the Germans are probably doing just at this time are not wholly persuasive to us. A computation as to their scraps of paper would carry greater conviction.

We desire to express our sincere obligations to the officers and staff of the West Virginia Pulp & Paper Company, for their courtesy in permitting us to publish the above details of their work and their industrial adventure in this interesting field.

Japan's Electrochemical Industry.—The electrochemical industry of Japan has made enormous strides during the past three years, according to *Denkinotomo*, the Japanese electrical semi-monthly magazine. At the beginning of the war it was one of the minor industries of the country, being grouped with the allied industries. In 1915 it was separately reported, its product being valued at 61,600,000 yen. In 1916 it increased to 117,727,211 yen, while for 1917 indications point to a 300,000,000 yen (\$150,000,000) output. The official returns for the past year have not yet been completed.

Splitting Limits in Colorado.—The customary splitting limits as usually agreed upon in ore buying contracts in Colorado are as follows:

| | |
|-----------------|------------------|
| Gold | 0.02 of an ounce |
| Silver | 0.50 of an ounce |
| Copper | 0.50 per cent |
| Lead | 0.50 per cent |
| Zinc | 1.00 per cent |
| Iron | 1.00 per cent |
| Insoluble | 1.00 per cent |
| Sulphur | 1.00 per cent |

¹Loc. cit.

Simple Washing in the Filter-Press

By D. R. SPERRY

TO WASH in a filter-press means to cause a liquid, usually water, to pass through the solids contained in the chambers, displacing from the voids therein some liquid which is not desired in the cake. Washing may also be employed for the purpose of dissolving some solid substance from the cake which may later be recovered from the wash-water. Instead of water, other liquids may be used with which to displace the liquid in the cake or to dissolve some portion of the solids in the cake. Thus it can be seen that washing, lixiviation or extraction may be carried on in the filter-press without removing the solids from the chambers. Indeed the above functions may be performed upon the solids in a filter-press by merely operating the proper valves. If desired, the wash-water can enter the filter-press by a separate channel and leave by a separate channel, so that the connections for the wash-water entrance and for the wash-water exit may be made permanent.

KINDS OF WASHING

There are two separate and distinct kinds of washing employed in the filter-press, namely, simple washing and thorough washing. The first is not necessarily less

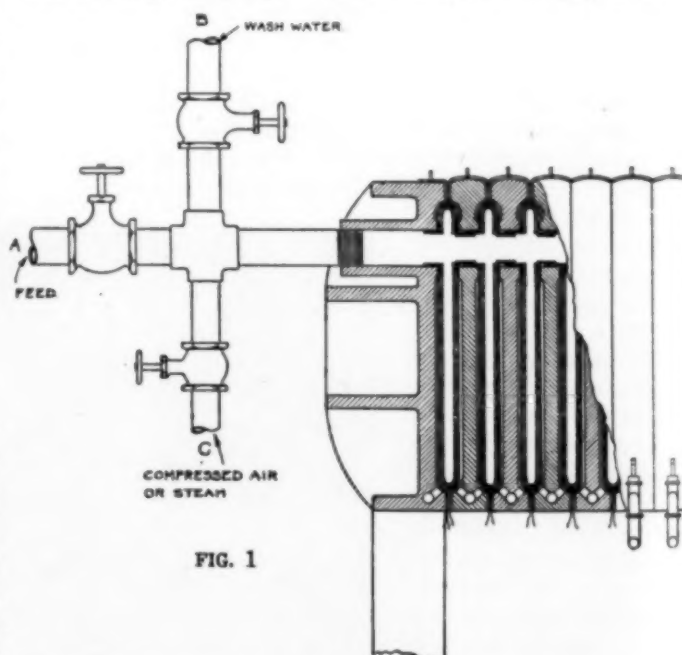


FIG. 1

thorough than the second, but it is much simpler in operation and can be used only in special cases to advantage. This kind of washing is used in the so-called self-dumping filters only because it is impossible to use thorough washing in that kind of filter. Selection of which of the two types of washing should be used in the filter-press depends upon the character of solids in the substance to be filtered and upon its chemical nature as regards acidity or alkalinity. The kind of filter-base used may also be a controlling factor as to whether simple or thorough washing is the most suitable to use.

SIMPLE WASHING

In simple washing the filling of the chambers of a filter-press must stop before the solids forming on

the filter-base have met each other. In other words, filling of the filter-press must stop while there is still an unfilled space down the center of the chamber. A filter-press which has reached this point of filling is shown in cross-section in Fig. 1. When this stage is reached the material which is being fed into the filter-press is closed off, as would be done if valve *A* were closed, and valve *B* running to wash-water supply opened. The pressure of the wash-water should be equal to or greater than that used in filling the filter-press. Under these conditions the wash-water soon displaces the mixture remaining in the unfilled space and itself passes through the deposited solids, against the plate surface and out through the cocks the same as the filtrate did during the filling process. The washing process is allowed to continue until the issuing wash-water indicates by its physical or chemical characteristics that the desired effect upon the solids has been reached. The wash-water is then closed off, and frequently compressed air is admitted into the filter-press as would be done by closing valve *B* and opening valve *C*. The effect of the air is to displace the wash-water remaining in the center of the cake as well as a certain amount of that held by the cake itself. In other cases steam instead of air may be admitted through valve *C*, this having the effect of displacing the wash-water and also of drying the cake to a certain extent.

SIMPLE WASHING WITH SEPARATE CONNECTIONS

In the case of simple washing just described it will be noted that no change whatever in the internal arrangement of the filter-press was necessary, the wash-water, air, or steam entering the chambers along the same path used by the material to be filtered. The wash-water thus issues from the filter-press cocks and into the gutter. It frequently happens that it is not

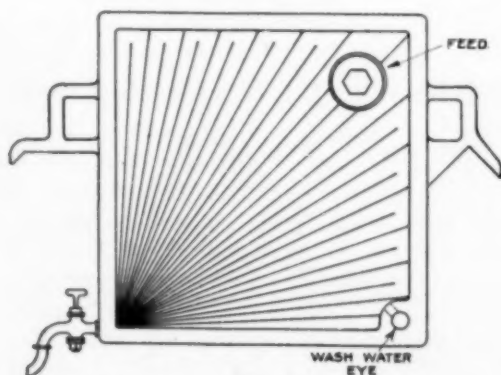


FIG. 2

desirable to have the wash-water or solvent leave the filter-press via the cocks and gutter. In that case a separate outlet for the wash may be arranged.

This is brought about by placing an eye usually in the lower corner of the plate opposite the cock. This eye has a port which connects it with the surface of the plate. A plate of the recessed type having a separate outlet for wash is shown in Fig. 2. When plates with a wash-outlet eye as shown are placed in a filter-press, the wash eyes register with each other, forming a continuous channel from one end of the filter-press to the other, one end of the channel being formed by the movable head, the other by an inlet placed on the fixed head. Due to the ports which connect the eyes with the

plate surfaces, the wash channel connects, as it were, all of the plate surfaces in parallel. The wash channel is of course separate and distinct from the feed channel.

In Fig. 3 a cross-section is shown through a filter-press arranged for simple washing with separate outlet for wash. Two sections are shown, the upper one is taken through the feed-inlet and the cock-outlet, while the lower one passes through the center of the plate and the wash-outlet channel. A study of the upper

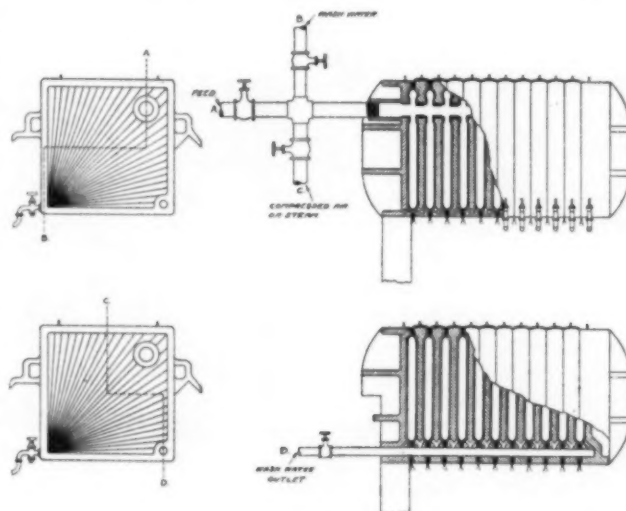


FIG. 3

cross-section shows that the material fed into the filter-press through the inlet located in the fixed head traverses the entire length of the filter-press by means of the openings through the grommets, thus filling all of the chambers formed by the recesses in the plates. During the feeding operation the valves *B*, *C* and *D* are closed while *A*, of course, is open. The material to be filtered is pumped or otherwise forced into the filter-press. As the chambers formed by the recesses in the plates are bounded by canvas or some other filter-base, the solids are caught on it while the liquid passes through filter-base and deposited solids, issuing from the back side of the filter-base and against the surface of the plates. The liquid reaching the surface of the plate is conveyed by means of grooves directly to a lower corner of the plate and out of the filter-press by way of a cock placed at the corner to which the grooves lead.

The filling process, as the depositing of the solids is called, is allowed to continue until a layer of solids is formed on the sides of the chamber of such a thickness that the chamber is not filled solid but an open space left in the center of the chamber. In other words, the solids on opposite sides of the chamber are not allowed to build up until they touch each other, but the process is stopped while there is yet a space between them. At this point it is well to note that if thorough washing, instead of simple washing, were to be employed, the chambers would be allowed to completely fill, instead of only partly fill as in the case considered. When filling has progressed to the proper point, valve *A* is closed, valve *D* opened, valve *B* opened and all of the cocks closed. When this is done the wash-water flows to all the open spaces purposely left down the center of each chamber, following the same route as that previously

taken by the material to be filtered. The wash-water soon displaces the material to be filtered which occupied the open places in the chambers, and itself passes through the deposited solids. As it issues on the back side of the filter-base it flows down the grooves on the plate surface, and, since the cocks are all closed, must flow into the wash channel formed by the eyes in the lower corner of the plate, as shown in cross-section in the lower part of Fig. 3. The pipe connected to the filter-press head at *D* conveys the issuing wash-water to any desired point.

The washing process is allowed to continue until the desired substance has been dissolved or displaced from the solids through which it flows. Chemical or physical tests of the issuing wash-water indicates when the process has continued long enough. When washing is finished valve *B* is closed and the filter-press may be opened ready for another cycle. If, however, it is desired to displace a large portion of the wash-water, valve *C* is opened, thus admitting compressed air or steam. This is allowed to continue until very little wash-water issues from the filter-press, at which point valve *C* is closed. It should be noted that if desired valve *D* may be closed and the cocks opened in order to allow the air or steam to discharge into the gutter.

In Fig. 4 a view is shown of a filter-press arranged

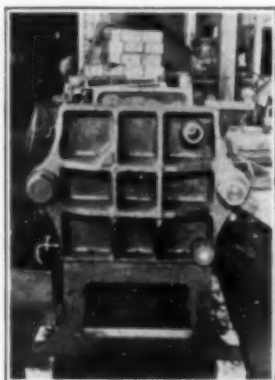


FIG. 4

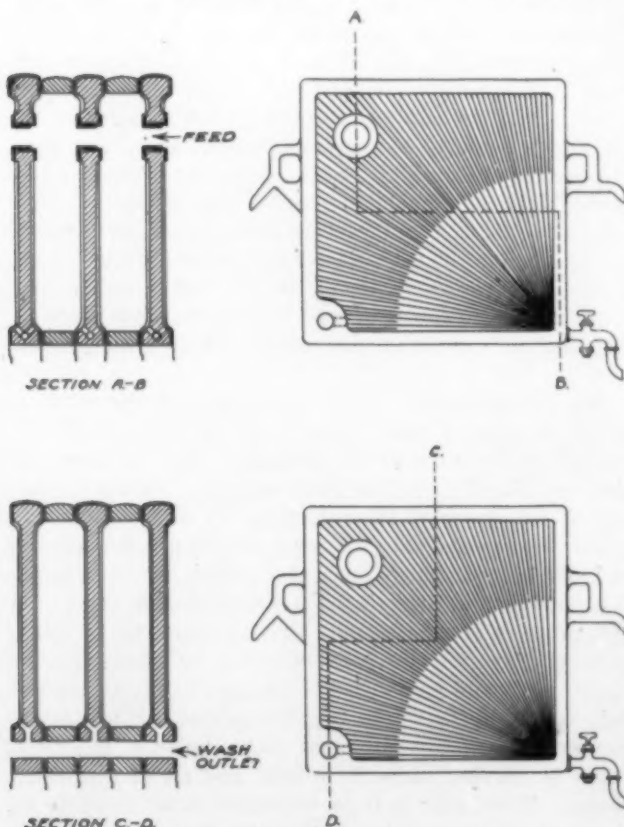


FIG. 5

for simple washing with separate outlet for wash. The inlet is shown in the upper corner, while the outlet for wash-water can be seen in one of the lower corners. The connections for feed, wash-water, air or steam, and wash-outlet can be seen. The cocks and gutter which carry off the filtrate can be observed along one side of the apparatus.

It can readily be understood that if desired, frames can be placed between the recessed plates, forming a wider chamber. In the lower corner of the frame, cor-

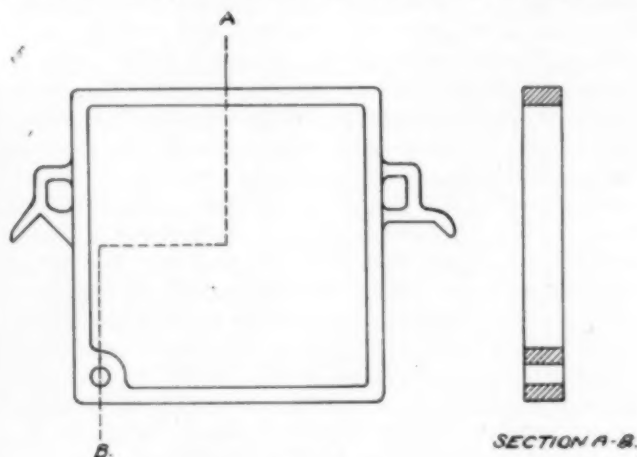


FIG. 6

responding to that in which the wash-water outlet-eye is placed on the plates, an eye must be placed in order to preserve the continuity of the wash-water outlet channel. In Fig. 5 is shown a few plates in cross-section having frames between them. Two cross-sections are given; one, the upper, through the feed-inlet and cock-outlet, the other, the lower, through the center of the plate and the wash-water outlet channel. A picture of the frame is shown in Fig. 6.

New Officers of the Engineering Council

At the first annual meeting of the Engineering Council, on Feb. 21, J. Parke Channing was elected chairman, Harold W. Buck first vice-chairman, George F. Swain second vice-chairman and Alfred D. Flinn secretary. The following committees were appointed:

Executive committee: The Chairman, the two vice-chairmen, and David S. Jacobus, Calvert Townley, George J. Foran.

Finance committee: E. Wilbur Rice, Jr., chairman; Charles F. Loweth, Sidney J. Jennings, David S. Jacobus.

Rules committee: J. Parke Channing, chairman; Clemens Herschel, Nathaniel A. Carle, Irving E. Moulthrop.

Public affairs committee: Charles Whiting Baker, chairman; George F. Swan, Benjamin B. Thayer, E. W. Rice, Jr., Charles E. Skinner.

American engineering service: George J. Foran, chairman; George C. Stone, Alfred D. Flinn, Dr. Addams S. McAllister, Edward B. Sturgis, secretary.

War committee of technical societies: D. W. Brunton, chairman; Arthur H. Storrs, secretary; James M. Boyle, Nelson P. Lewis (American Society of Civil Engineers), Edmund B. Kirby (American Institute of Mining Engineers), A. A. Greene, Jr., R. N. Inglis (American Society of Mechanical Engineers), Harold W. Buck, Dr. Addams S. McAllister (American Institute of Electrical Engineers), Dana D. Barnum, E. C. Uhlig (American Gas Institute), Joseph Bijur, Dr. Charles A. Doremus (American Electrochemical Society), Louis B. Marks, Preston S. Millar (Illuminating Engineering Society), Christopher R. Corning, George C. Stone (Mining and Metallurgical Society of America), Henry Torrance, F. E. Matthews (American Society of Refrigerating Engineers).

Report of Smelter and Ore-Sales Investigation Committee, State of Colorado, 1917

IN RESPONSE to a popular demand which has been rather insistent in some parts of Colorado for several years, the General Assembly in 1917 authorized the appointment of a Smelter and Ore Sales Investigation Committee to inquire into the buying, selling and treatment of ores and concentrates in Colorado, and to make such recommendations regarding charges or schedules as might be appropriate. The committee comprised two members of the State Senate and three of the House of Representatives, and the sum of \$15,000 was appropriated for their use. Mr. O. R. Whitaker, a consulting engineer of Denver, was employed by the committee to make a technical investigation and report.

Hearings were held in Georgetown, Idaho Springs and Central City, where a number of witnesses appeared. The testimony was, for the most part, a repetition of the same statements, and the hearings were discontinued.

TYPICAL TESTIMONY AT HEARINGS

Mr. A. E. SIMPSON of Georgetown presented testimony which is typical of the attitude of the small ore-producer. He found no objection with sampling methods nor with the accuracy of the financial returns. His main objection was that the schedules are designed to mystify the ordinary miner, are quite arbitrary in their provisions, and do not return to the producer fair proportion of the metal value of the ores. The latter objection, i.e., that the schedules are not high enough, has lost some of its force because new schedules were issued about the time the investigation started, wherein the miner is paid 75 per cent of the market increase, over the base rate for lead, rather than 50 per cent as formerly. Mr. Simpson was of the opinion that, although returns in recent years were greater due to increased market value of metals, they were not in proportion to the increased cost of ore production.

Mr. FRED S. CALDWELL, general manager for the C. H. W. Mining Co., of Central City, stated the manager's position. He said that the committee was charged with determining the answers to the following questions:

- (1) What does it cost to smelt the different ores of the various mining districts of Colorado?
- (2) What are the actual losses on the different metals during the smelting of their ores?
- (3) What is the actual cost of refining base lead bullion and copper matte containing gold and silver?
- (4) What are the losses on metal content in the refining of base lead bullion and copper matte containing gold and silver?

Mr. Caldwell exhibited settlement sheets on 41 lots of ore shipped during 1916, which have been summarized in Table I.

In explanation of this table, "Metal Content Less Deductions for Loss in Smelting" represents the sum of the dry weights multiplied by the assay. The analysis of the lead and copper is reduced by 1½ per cent (1 per cent since Sept. 1, 1916, according to the new

TABLE I—SUMMARY OF 41 LOTS SHIPPED BY THE C. H. W. MINING CO.

| Metal Content Less Deductions for Loss in Smelting | MARKET VALUE 90 DAYS FROM SALE | | RETURNS TO MINER | | Gross Margin | REFINERY CHARGES PLUS FREIGHT ON METAL | | Net Margin |
|--|--------------------------------|---------|------------------|---------|--------------|--|-----------|------------|
| | Total | Average | Total | Average | | Rate | Am't | |
| Au 1,386.14 oz. | \$28,651.36 | \$20.67 | \$27,002.33 | \$19.48 | \$1649.03 | ..... | \$151.37 | \$1846.94 |
| Ag 9,791.28 oz. | 7,070.18 | \$0.722 | 6,720.90 | 0.686 | 349.28 | ..... |  |  |
| Pb 168,181.5 lb. | 12,744.34 | 7.58c | 6,432.19 | 3.82c | 6312.15 | 1.01c/lb. | 1698.63 | 4613.52 |
| Cu 14,163.8 lb. | 4,126.70 | 29.13c | 3,290.91 | 23.23c | 835.79 | 1.6c/lb. | 226.62 | 609.17 |
| Total | \$52,592.58 | | \$43,446.33 | | \$9146.25 | | \$2076.62 | \$7069.63 |

schedule), which deduction is explained by the ore purchaser as covering the loss in smelting. It is supposed that it requires 90 days to smelt, refine and market the metal; consequently the second column represents the value of the metal 90 days after it was accepted by the smelter. "Returns to Miner" represents the amount paid by the smelter less the treatment charges and freight. The "Gross Margin," therefore, represents the gross profit accruing on these shipments. The unit "Refinery Charges" were taken from *Technical Paper* 83, Bureau of Mines, by C. H. Fulton, and the gold and silver purification estimated at 0.09 cents per pound of lead. "Net Margin" represents the smelters' profit above the profit on the treatment charge, and the refiners' outfit, i.e., an investment of \$43,446.33 pays \$7,069.63 in 90 days, which is at the rate of 65 per cent per annum.

Mr. Caldwell submitted that if this analysis is not correct, and the indicated profit is too high, it is because (a) the treatment charge assessed by the smelter is too low, (b) the deductions for metal loss in smelting are too small, (c) the refining cost is too low, or (d) there exist large refining losses which are not included. He also expressed the opinion that the producer should have the option of receiving metal in return for his ore, after paying a proper treatment charge; this would avoid the necessity of heavy charges assessed by the smelters supposedly to protect themselves against violent market fluctuations.

Mr. ROBERT H. SAYRE, mining engineer of Central City, presented the views of the Gilpin County Mining Association. He compared contracts offered by the U. S. Smelting Co. in Utah with the schedules of the American Smelting & Refining Co. in Colorado, in which the former appeared much more reasonable. For instance, the Utah smelter pays for gold if above 0.02 ounce, against 0.05 ounce in Colorado. Copper deduction for smelting losses is 0.6 per cent in Utah and 1.5 per cent in Colorado, while the price deduction is 2½ cents below quotation, against 6 cents.

REPORT OF COMMITTEE'S ENGINEER

The results of the technical investigation made by Mr. O. R. Whitaker are given in the form of typical

schedules, together with an analysis of the cost of ore treatment in Colorado. His report covers operations during a period of five years from January, 1912, to December, 1916, inclusive, and deals with ores containing gold, silver, copper, lead and zinc in commercial quantities. In figuring plant depreciation, he assumed that the life of the plant is 10 years, and a charge of 10 per cent on plant valuation is made to cover this item. Interest charges are figured at 5 per cent per annum. Average annual metal prices are used in computing metal values for the period under review. A summary is given in Table II.

ORE BUYING AND SELLING

The buying and selling of ores and metallurgical products, like any other industry, has but one object in view, that is to show a profit on the business done. It is a commercial transaction in which each party uses the knowledge he has in the protection of his interests.

The mills and smelters have always a clear knowl-

with the total cost of treatment, metal losses, refining, marketing, depreciation and interest in addition to their own profits. In determining the ultimate profits on the business, the time between the settlement for the ores to the producer and the realization on the product is very important. Where large stocks of ores are carried at the plant and the amount of refined or semi-refined product in transit is large, sudden variations in the market price of the metals have a decided effect on the increase or decrease of the profits.

In times of high metal prices, ore production is stimulated and stocks are consequently increased. With a low metal market the reverse is true. Also, except under abnormal conditions, the market declines more rapidly than it rises. Therefore, unless some provision is made for the protection of the purchaser of ores carrying metals which fluctuate in price, a loss is more likely to occur than a gain.

Ores are purchased in the open market as offered at the terms agreed upon, and usually without obligation on the part of the producer as to quantity. Time contracts are often made with producers when special ingredients are supplied or a definite tonnage of ore assured.

With a treatment plant operating in, or tributary to a substantial ore supply, it would be impossible to settle for and treat the ores from the various mines immediately on the date of receiving them. Therefore it is necessary to settle on some agreed basis.

No metallurgical process recovers all the metal values from the ores. Therefore the payment for the full metal content at market prices cannot be expected. Deductions are made for treatment, losses, marketing, etc., and paying bonuses where required, making necessary some form of ore selling contract.

The existing ore schedules are the result of a gradual evolution of the ore purchasing business, and in some form or other take into account, by direct treatment, charges or metal deductions, the items of principal importance to the purchaser. Inasmuch as these schedules are drawn to cover, in one contract, the business of paying for the values in the ore, the treatment, the losses in the treatment, the refining and selling of the recovered products, the bonuses and penalties and a protection to the purchaser from loss due to sudden market fluctuations, they are complex. In their use for calculating the value of an ore to a plant, a system of discounts and charges is necessary.

TYPICAL MILL AND SMELTER SCHEDULES CUSTOM CYANIDE MILL SCHEDULES

The following is a representative schedule for Cripple Creek gold ores treated in custom mills and smelters, prices f.o.b. district, gold at \$20.00 per ounce:

CUSTOM CONCENTRATING MILL SCHEDULE

| | |
|----------------------------------|--------------------------------------|
| Value up to \$10.00 per ton, | \$4.00 per ton freight and treatment |
| From \$10.00 to \$15.00 per ton, | 5.00 per ton freight and treatment |
| From 15.00 to 20.00 per ton, | 6.00 per ton freight and treatment |
| From 20.00 to 25.00 per ton, | 6.25 per ton freight and treatment |
| From 25.00 to 30.00 per ton, | 6.50 per ton freight and treatment |
| From 30.00 to 40.00 per ton, | 7.00 per ton freight and treatment |
| Over 40.00 per ton, | 8.00 per ton freight and treatment |

Schedules for the purchase of ores to be treated in concentrating and separating plants are complex in that they are used to calculate the price to be paid for ores containing several metals. These schedules usually start with a *base price*, for ores of a certain metal con-

TABLE II—SUMMARY OF OPERATION OF COLORADO ORE-TREATMENT PLANTS

| | Colorado Ores Treated in Custom Mills 1912-1916 Incl. | Colorado Ores Treated in Custom Concentrating and Separating Plants, 1912-1916 Incl. | Colorado Ores Smelted in Colorado Zinc Plants, 1912-1916 Incl. | Colorado Ores Smelted in Colorado Lead Smelters, 1912-1916 Incl. | Outside Ores Smelted in Colorado Lead Smelters, 1912-1916 Incl. | Total Ores Smelted in Colorado Lead Smelters, 1912-1916 |
|---|---|--|--|--|---|---|
| Ore treated, tons | 2,508,933 | 1,025,000 | 79,752 | 3,140,018 | 734,688 | 3,874,706 |
| Value of ore stock | | | \$215,000 | | | \$1,095,400 |
| Value of product in transit | \$750,000 | \$550,000 | 125,000 | | | 2,300,000 |
| Time in process, days | 30 | 45 | 45 | | | 60 |
| Value of plant | \$1,850,000 | \$1,150,000 | \$500,000 | | | \$2,700,000 |
| CREDITS | | | | | | |
| Gross metal value | \$19.06 | \$35.11 | \$74.11 | \$36.86 | | |
| Paid shipper and freight | 13.81 | 16.96 | 28.77 | 17.95 | | |
| Margin for treatment | \$5.25 | \$18.13 | \$45.34 | \$8.91 | | |
| DEBITS | | | | | | |
| Cost of treatment | \$2.00 | \$3.00 | \$21.47(a) | | | \$4.35 |
| Metal losses | 1.14 | 10.53 | 13.98 | | | 1.34 |
| Refining and marketing | 0.25 | 2.10 | 1.17 | | | 1.66 |
| Total | \$3.39 | \$15.63 | \$36.59 | \$7.35 | | \$7.33 |
| Operating profit | \$1.86 | \$2.50 | \$8.75 | \$1.56 | | |
| Taxes, depreciation (10%) and interest (5%) | 0.40 | 0.40 | 1.50 | 0.61 | | |
| Average net profit per ton | \$1.46 | \$2.10 | \$7.25 | \$0.95 | | |
| Per cent of gross value | 7.6% | 6.0% | 9.7% | 3.5% | | |
| Analysis: | | | | | | |
| Au (oz.) | 0.92 | 0.02 | 0.22 | 0.526 | 0.684 | 0.439 |
| Ag (oz.) | 0.08 | 2.50 | 6.6 | 12.34 | 44.95 | 18.53 |
| Cu | | Trace | | 0.61 | 0.52 | 0.64 |
| Pb | | 5.5 | 4.0 | 6.76 | 32.65 | 11.67 |
| Zn | | 16.0 | 35.5 | | | |

(a) Includes \$1.94 for residue treatment.

edge of the results of their operations, such as cost of production, treatment, recovery, losses and the price of the product, from which they figure how much will be made on each ore purchase. The producers and sellers of the ores are possibly not so familiar with the details of the treatment processes used, therefore a clear explanation of the contract would be of great assistance to them.

Since the reduction plants, such as mills and smelters, are built solely for the business of ore treatment, the expense of their operation must necessarily come from the realization of the metal values extracted from the ores treated. It is necessary, therefore, for the companies when purchasing ores to charge the producers

tent at a fixed market price and stated delivery. Unit variations are added or deducted according to the grade of the ore and market variations are also allowed and figured on the market price of the metals affected and are calculated from a stated quotation given in the contract. The gold and silver are usually paid for at a certain price per ounce within specified limits.

There is usually no direct treatment charge made in the purchase of these ores. The cost of treatment, metal losses, etc., together with the profit, is made up from deductions from the various metals contained.

A representative schedule on a zinc-lead-iron sulphide ore is as follows:

Base price per ton, f.o.b. Denver, \$6.15

Normal analysis: Zn 25 per cent
Ag 5 oz.
Pb (wet) 5 per cent
Insoluble 7%

Normal metal price, Zinc 5.5c. per lb. St. Louis quotation

Lead 5.5c. per lb. New York quotation

Unit variations:

Penalty for insoluble: 5c. for each per cent above 7.

Zinc: $\pm 43c.$ for each per cent above or below 25 per cent

Lead: $\pm 40c.$ for each per cent above or below 5 per cent

Silver: $\pm 30c.$ for each ounce above or below 5 per cent

Market variation:

Zinc: 7c. per unit (20 lb.) for each \$1.00 change in spelter quotation from \$5.50 to \$7.00.
3½c. per unit from \$7.00 to \$13.00 maximum.

Lead: 7c. per unit for each \$1.00 change in lead quotation from \$4.50 to \$11.00 maximum.

Gold: \$8.00 per oz. from 0.04 oz. to 0.10 oz.
10.00 per oz. from 0.11 oz. to 0.20 oz.
12.00 per oz. from 0.21 oz. to 0.30 oz.
14.00 per oz. over 0.30 oz.

ZINC SMELTER SCHEDULE

Schedules for the purchase of zinc ores are made up from a base price, at a given market for ores of a specified grade. Unit and market variations are according to grade and metal quotations. The deductions made provide for the treatment, metal losses and profit to the smelter. For the operations of the Colorado zinc plants ores containing gold and silver are preferable, and a schedule similar to that used by the concentrating plants would be more preferable than the following:

Representative Schedules for Zinc Ores

F.o.b. Missouri river points. Based on 5c. spelter market.

| Oxidized | | Sulphides |
|--------------------|--|--------------------|
| 25 to 45 25% | Metal content, % Zn. | 38 to 50 |
| \$21.00 for 40% Zn | Minimum metal content, % Zn. | 38% |
| \$1.00 | Base price, per ton of ore. | \$26.95 for 50% Zn |
| | Unit variation, up or down. | \$1.00 |
| 60% of value | Market variation:— | 75% of value |
| | Market from \$5.00 to \$6.00 per 100 lbs. | |
| +50% of value | Market from \$6.00 to \$15.00 per 100 lbs. | +50% of value |
| +40% of value | Market above \$15.00 per 100 lbs. | +50% of value |

COPPER-LEAD SMELTER SCHEDULE

Schedules for the purchase of copper-lead ore are usually complex. In order to cover its expense, the smelter usually pays for a percentage of the actual contents of the ore at a price below the market quotation.

For gold in ores, no payment is made for gold of 0.03 oz. or lower, and in some cases if less than 0.05 oz. is present. Also, a price of \$19.00 to \$19.50 per ounce is paid for the gold, as compared to the actual value of \$20.67, which two deductions are intended to cover losses in smelting, marketing, etc.

Ninety-five per cent of the silver content in ores is usually made; likewise no payment is made if the content is less than 1 or 2 oz. per ton.

For copper, a deduction of from 1.0 to 1.5 per cent is made at the quotation, less 3 to 6 cents per pound, depending upon the grade of the ore. Furnace practice in treating copper ores in lead smelters shows an average loss of 5 to 6 lb. of copper per ton of ore treated. The customary deduction of 1.5 units for loss is an arbitrary one and is governed by the quantity of copper ores received by the smelter during a definite period. Since copper is not contained in all ores received by the lead smelters, slag absorption will cause loss continuously, which must be provided for.

Payment for the lead in ores may be made by deducting from 1.0 to 2.0 per cent for the wet analysis to arrive at the so-called "dry-assay," and the balance computed from the current quotation, which is generally figured from the New York sales price of the American Smelting & Refining Company on the date of settlement. In case this sales price, or "quotation," is \$4.00 per 100 lb. or less, the seller of the ore received 90 per cent of the quotation for the lead in his ore shown by the dry assay. Should the quotation be over \$4.00 per 100 lb., the seller of the ore also receives one-half (or three-quarters in some instances) of the excess. The excess deduction is designed to be a protection for the purchaser against sudden market fluctuations.

In case the settlement is made under the "Unit and Quotation" system, a base price per unit (B) is given in the schedule which varies with the lead-content of the ore. This base is on the supposition that the quotation for lead is \$4.00 per 100 lb., and for Clear Creek, Gilpin and Boulder districts is as shown in Table III.

TABLE III

| Dry Lead, Per Cent | Base Price per Unit, Cents |
|--------------------|----------------------------|
| 5 to 10 incl. | 40 |
| Over 10 to 15 | 43 |
| Over 15 to 20 | 45 |
| Over 20 to 25 | 47 |
| Over 25 to 30 | 49 |
| Over 30 to 35 | 51 |
| Over 35 to 40 | 52 |
| Over 40 to 45 | 52 |
| Over 45 to 50 | 53 |
| Over 50 to 55 | 54 |
| Over 55 | 55 |

In case the quotation (Q) is more than \$4.00, the price paid per unit is figured from the following formula:

$$\text{Price} = B + \frac{\$3.60 + \frac{1}{2}(Q - \$4.00) - \$4.00}{5}$$

In case the quotation (Q) is less than \$4.00, the price is figured as

$$\text{Price} = B - \frac{\$4.00 - (Q \times 90 \text{ per cent})}{5}$$

From a large number of schedules given in Mr. Whitaker's report, those in Table IV are representative.

The non-payment for the metals below a certain limit is intended to cover losses and give a commercial protection to the smelters. When these ores are smelted with ores carrying enough of the metals to take care of their proportion of the slag absorption and other losses, then all the excess above this is recovered.

In ores containing under 5 per cent lead, the lead is sometimes paid for as iron at 15c. per unit, but usually nothing is paid. In smelting this ore together with sufficient high-grade ore to bring the lead on the charge high enough for furnace requirements, all of the lead in excess of 30 lb. per ton would be recovered, according to general practice. The commercial reason for this

TABLE IV—SCHEDULES OF ORES AND CONCENTRATES TO LEAD-COPPER SMELTERS, FROM CLEAR CREEK, GILPIN & BOULDER DISTRICTS, COLORADO
Rates f.o.b. cars Denver. Minimum shipment, 1 car-load.

| | General Schedule, All Classes Ores and Concentrates | Dry Concentrates | Special Schedule, Lead Ores and Concentrates | Lead Concentrates |
|-------------------------------------|---|--|--|----------------------|
| Gold, per oz., 0.05 oz. to 2.00 oz. | \$19.00 | \$19.00 | \$19.50 | \$19.00 |
| Gold, per oz., 2.00 oz. and over | 19.50 | 19.50 | 19.50 | |
| Silver, if 2 oz. or over | 95% N. Y. quotation | 95% N. Y. quotation | 95% N. Y. quotation | 95% N. Y. quotation |
| Dry copper—wet assay less 1.5%: | | | | |
| Up to 5% | Casting copper —6c | Casting copper —6c | Casting copper —6c | |
| 5% to 10% | Casting copper —5c | Casting copper —5c | | |
| 10% or more | Casting copper —4c | Casting copper —4c | | |
| Silica (insoluble): | | | | |
| Limit | | 10% | | 10% |
| Penalty per unit | | 10c | | 10c |
| Zinc: | | | | |
| Limit | 10% | 5% | 10% | 10% |
| Penalty per unit | 50c | 30c | 50c | 50c |
| Dry lead—wet assay less 1.5%: | | | | |
| Up to 5% | None | | | |
| 5% or more | 25c/unit | | | |
| Base prices per unit | | | See table above | See table above |
| Treatment Charges | Gross Value Up to \$14 5.00 \$14 to \$20 6.00 20 to 25 6.50 25 to 30 7.00 30 to 35 7.50 35 to 40 8.00 40 to 45 8.50 45 to 50 9.00 Over \$50 10 | Charge Up to \$35 3.50 \$35 to \$80 4.00 Over \$80 4.50 | See Figure 3 | Figure 3 |

deduction is that the lead content is below smelting requirements, and this ore can only be treated to advantage along with a higher grade lead ore. The limited supply of high-grade lead ores therefore controls the smelting capacity on low-grade lead ores. These low-grade ores are not profitable to the smelter for their lead content when considered by themselves, as they can only be smelted by recharging bullion into the furnace, to bring up the lead on the charge, thereby increasing losses and costs.

The average lead content of the Colorado ores smelted from 1912 to 1916 was 6.76 per cent. Since this is below the requirements for economic lead smelting, the deficit therefore must be made up by the purchase of high-grade ore from outside the state.

GENERAL REMARKS ON SMELTING

ZINC SMELTERS

The main requisites for a zinc smelter are cheap ore and cheap fuel. Where by-products are made, market-

ing facilities are also important. The Eastern zinc smelters are in the natural gas fields furnishing cheap fuel. The Missouri and Oklahoma ores are higher in grade and cheaper to produce than the Colorado ores and are more desirable for a zinc smelter. Owing to the increased cost of operation in Colorado, only crude ores of special composition are available, mainly impure complex zinc ores carrying gold and silver values.

The losses in zinc smelting are high and fuel consumption is heavy. The usual practice figures a loss of 8 units of metallic content and from 2½ to 3 tons of fuel per ton of ore smelted. Losses in percentage would vary from 12½ per cent on a 64 per cent zinc ore to 25 per cent on a 32 per cent ore. These losses are due to absorption by retorts (which is not recoverable), impurities, burning of zinc, and the formation of non-recoverable compounds. The deduction for freight would depend upon the location of the plant. Treatment charges will vary \$16.00 to \$22.00 per ton of ore.

LEAD SMELTERS

Low-grade ores are frequently produced in the prospecting for high-grade ores and also incidentally to the production of the latter. A sliding scale of treatment and purchase of these low-grade ores is justifiable in order to stimulate production. The loss to the smelter in smelting the low-grade ores must be borne by the high-grade ore in order to bring the average to a reasonably profitable basis. Should this not be done, the operations would be on a smaller scale, with proportionately increased costs for both.

In order to successfully operate a smelter the mixtures going to the furnaces cannot be varied from hour to hour. Therefore the smelters desire large and regular shipments. In consideration for a guaranteed supply of a definite tonnage at a fixed rate, concessions are made and these shipments are purchased under more favorable terms than the small irregular shipments. A small shipment requires as much work for the assaying and general charges as a large one, making the cost of handling proportionately higher.

A comparison of the open schedules with the average contract schedule, under which the bulk of the ore is purchased, would not be favorable to the shipper, because a contract for a guaranteed tonnage of ore of a desired content at a specified rate would be given advantages over the open schedule which represents small and intermittent shipments.

The essential requirement for a lead smelter is an ore mixture, to be so apportioned that a slag can be formed, from which the recovery of the metal values is made. The metallurgist may often have to sacrifice good practice to obtain the greatest profit. Barren fluxes not only cost money but also take up space and reduce the capacity. When fluxes contain metals of value they may be classed as a low-grade ore and treated accordingly. These low-grade ores may be purchased under special and variable rates according to the requirements of the plant. The slag formed from smelting an ore or a combination of ores will contain appreciable amounts of gold, silver, copper and lead, as well as the other constituents, no matter whether all the original ores contained these metals or not.

In smelting sulphide ores, roasting is necessary in preparation for the blast furnace, thus involving an

extra expense of operation and an increased metal loss due to volatilization.

The quantity of fuel required varies from 8 to 12 per cent, depending upon the amount of sulphur, the lead on the charge, and the temperature of the formation of an easy running slag.

The principal products from the blast furnace are slag, flue dust and fume, matte, speiss and bullion. All of these products contain metal values, and with the exception of the slag, must be retreated for their recovery.

When the ores contain small amounts of copper, as in the case of smelting lead-copper ores, retreatment is necessary to bring the copper into a marketable form for further concentration. Each stage of the retreatment involves the usual losses so that the ultimate recovery is relatively small.

The final recovery of lead from the ore in the average copper-lead furnace charge requires from one and one-quarter to two smeltings. For the recovery of the copper in the form of high-grade matte, two and one-half to three smeltings are required.

In cases where the amount of lead on the charge is small, in the first operation, the recovery in bullion will be about 65 per cent, in by-products to be retreated about 15 per cent, lost in the slag about 10 per cent, and 10 per cent will be volatilized. Part of the latter may be recovered in baghouses, according to the plant equipment. For the efficient collecting of values in a lead smelter, the percentage of lead on the charge should be around 10 per cent. In order to smelt locally to the best advantage the ores of the average lead content such as produced, it is necessary to obtain lead from another source to bring the charge to the economic requirement.

During the five years' operation from 1912 to 1916 the Colorado smelters produced approximately 441,000 tons of lead bullion, 50 per cent of which came from Colorado ores.

In copper-lead smelting, zinc in the ore is detrimental. It decreases the fluidity of the slag and lowers the specific gravity of the matte, thereby interfering with the settling. Losses are also increased and furnace operations are hampered. All of the zinc in the ore is a loss to the lead smelter and the slag from the Colorado smelter carries from 5 to 10 per cent zinc. Other substances, such as alumina, manganese, lime and magnesia, act differently in the blast furnace and are penalized or credited accordingly. Iron is a necessary flux and has only that value to the lead smelter. It goes into the slag and cannot be economically recovered.

The best slags will contain from 0.002 to 0.005 of an ounce of gold, from 0.50 to 1.00 oz. of silver per ton, from 0.20 per cent to 0.30 per cent of copper, and from 1.0 per cent to 1.50 per cent of lead.

In the usual blast furnace practice with an 8 to 10 per cent lead on the charge, the slag made represents from 60 per cent to 65 per cent of the charge, or 1 ton of slag for each ton of ore smelted. The matte fall is held at about 10 per cent. The matte will contain approximately: gold 0.05 oz. per ton, silver 40.0 oz. per ton, copper 10 per cent, lead 15 per cent, zinc 10 per cent, and iron 40 per cent, together with other ingredients, such as silica, alumina, etc. The second matte contains 40 per cent copper or better.

The baghouse product will contain something like

40 per cent lead, 10 per cent zinc, and such other volatile metals as arsenic, antimony, cadmium, etc.

LOSSES AND REFINING

The losses incident to smelting are slag, volatilization, and mechanical. The losses of gold are small and are due to slag and mechanical losses. Smelter operations often show a gain in gold due to the non-payment for gold when less than 0.02 to 0.05 of an ounce in the ore. The loss in silver is in the slag and possibly a small mechanical loss, and is provided for by paying for 95 per cent of the silver content. The copper loss is in the slag. The lead losses are in the slag and in the flue dust.

In the usual practice the following summary of losses will be representative:

| | |
|--------|----------------------------------|
| Gold | 0.005 oz. per ton of ore treated |
| Silver | 1.0 oz. per ton of ore treated |
| Copper | 6 lb. per ton of ore treated |
| Lead | 30 lb. per ton of ore treated |

In addition to the actual metallurgical losses in the smelting operations, it is necessary that the schedule provide for the refining and marketing of the metals recovered. The cost of refining and marketing of the gold and silver is small and charged to the lead bullion. A representative bullion refining charge is \$25.00 per ton, which includes freight, etc., or one and one-quarter cents per pound ($1\frac{1}{4}$ cents) of lead. A representative refining charge on 40 per cent copper matte is \$40.00 per ton, including freight, etc., or five cents (5 cents) per pound of copper contained in the matte.

The refining and freight charges for the copper in lead ores are not to be compared with similar charges for the copper in an ore when sold to a copper smelter, as the latter ships a practically pure product, paying no freight on the impurities. A lead smelter ships 40 per cent copper matte and the freight for the same distance, other things being equal, would be two and one-half times as great.

CONCLUSION OF INVESTIGATING COMMITTEE

By reading the evidence in Mr. Caldwell's statement, it will be found that certain questions are asked by producers of ore. These questions embody completely the complaint against the smelters and ore buyers of the state.

The answers to three of these questions are found in Mr. Whitaker's report. In the matter of refining and marketing charges the committee has no power to investigate any corporation outside of the boundaries of the state and there are no refineries in Colorado. Hence we must submit only such facts as we have found. It costs $1\frac{1}{4}$ per cent per pound of lead to transport and refine bullion. It costs 5 cents per pound of copper to transport and refine copper matte.

In the matter of returns upon the investment the risk is taken upon the turnover and not upon the original investment. Hence fluctuation of the market in metal prices is the dangerous end of the smelting business. And as pointed out in the letter from the executive committee of the Colorado Metal Mining Association, the returns figured upon the investment of \$2,700,000 is approximately 27 per cent while when figured upon the turnover is less than 4 per cent.

The smelters contend that the valuation is not high enough; that while the valuation placed by Mr. Whit-

aker on the plants does cover the actual physical value, much money is expended in building and operating many experimental processes. Many of these have to be abandoned, and represent a total loss to the smelting companies, and hence the claim that a higher valuation should be placed in order to cover the item of depreciation. While there is, doubtless, much truth in this contention, the fact remains that the figures used by Mr. Whitaker are in excess of the assessed valuation of the plants. While it is probable the plants could not be reproduced at these figures at present, they could be in normal times.

In the matter of zinc ores, it appears that zinc smelting in Colorado is really not an important factor in determining the price of ore. Out of 1,167,205 tons of zinc ore and concentrates produced in Colorado, there was treated in Colorado zinc smelters only 79,755 tons, or less than 7 per cent of the total. The schedules and prices of such ores are made and determined in the great zinc smelting centers in other states. The price in Colorado for such ore is absolutely made outside of the state.

In the matter of lead ore—and that is the most important phase of the committee's work, for it is between the producers of lead ores and the buyers that most of the complaints have arisen—much may be said.

New schedules have been voluntarily put into effect by the smelters and ore buyers during the year 1917. It is admitted by many producers, and is doubtless true, that these schedules eliminate much of the ground of complaint. Nevertheless the basic complaint is with the schedule itself. The committee believes that no schedule based upon the unit and quotation system will ever be satisfactory to the producer. It is hard for many producers of ore to understand, and unfortunately the smelters and ore buyers make no strenuous effort to explain it to those with whom they do business. Hence grew the belief that they were unjustly dealt with. And the committee believes that such an impression will prevail as long as such schedules remain. In the opinion of the committee the introduction of a new and easy understood schedule would go far toward eliminating the complaints in this matter.

Another matter which is subject of much unfavorable comment is the fixed minimum of 5 per cent on lead ores. Mr. Whitaker's report shows the average contents of Colorado produced lead ores was 6.76 per cent. When under 5 per cent the smelters and ore buyers do not pay for the lead contents, the reason assigned being that the cost of treatment would balance the value of the ore. Mr. Whitaker in his report finds that it is necessary to send low-grade lead ores twice through the furnace, in which case, of course, the saturation of the slag is sure to occur. This causes a loss of 30 lb. to the ton or 1.5 per cent. The two operations would therefore consume 3 per cent of the charge or 60 per cent of the lead contents of a 5 per cent ore. Now the cost of treatment is borne by all the metals in the charge and hence only a portion of it should be borne by the low-grade lead ore. Doubtless this is a source of profit to the smelters.

The committee believes that either the minimum should be reduced to 3 per cent on lead ore, or that the producer should be given the opportunity to have his ores smelted and by paying the charges therefore receive the bullion on 5 per cent and lower lead contents.

In the matter of copper in ores, Mr. Whitaker plainly points out that on account of the lack of copper in most Colorado ores the saturation of the slag which is 6 lb. to the ton, takes most of the copper contents. In a lead smelter ore with copper contents must be treated with ore that has no copper and requires several operations, each entailing a loss by saturation of slag. While the minimum of 1 per cent or 1½ per cent is an arbitrary one it is probably founded upon results of experience. With three or four operations each entailing a loss of 6 lb. copper it can be plainly seen that 1 per cent copper in the original ore would be lost.

The committee believes that some system of licensing umpires should be established. Some competent authority should be established which would issue licenses upon proper examination, and with power to revoke such in case of dishonesty or improper return or careless work.

The complaint about equipment seems to be well founded. The committee believes that sampling works should be inspected and required to maintain a certain standard of equipment. This duty could be properly assumed by the Commissioner of Mines' department.

Government Controls Acetone Supply.—All of the acetone produced in the United States has been commandeered by the Secretary of War for the six months ending June 30, 1918. Supplies of this material can only be secured now by means of a permit. This may be obtained through Mr. C. H. Conner, Council of National Defense Raw Materials Division, War Industries Board, Washington, D. C.

William Gibbs Gold Medal.—Dr. William M. Burton, vice-president of the Standard Oil Co. of Indiana, has been awarded the 1918 William Gibbs gold medal by the Chicago Section of the American Chemical Society. Dr. Burton entered the employ of the Standard Oil Co. soon after receiving his doctor's degree from Johns Hopkins in 1889. He is best known through the Burton process of oil refining, which he developed and which was brought to the attention of the public in 1913. The process has been a big factor in increasing our gasoline supply.

Russian Production of Rare Metals.—The Russian Bureau of Mining reports that no bismuth was produced in Russia during 1916 (Commerce Reports). Antimony was produced in such small quantities that no statistics have been gathered. Of molybdenum (MoS_2), only 150 poods (5417 lb.) were produced, all of which was used for domestic purposes. The value cannot be ascertained. About 2000 poods (72,220 lb.) of tungsten, concentrated (60-65 per cent WO_3), was produced, the value of which is not given. The total amount was used in Russia. Since 1914 all bismuth, molybdenum and tungsten have been used for war purposes. In 1917 it is estimated that 6000 poods (216,680 lb.) of tungsten ore (65 per cent WO_3), 50 poods (1806 lb.) of bismuth ore (60 per cent Bi), and 200 poods (7220 lb.) of molybdenum (45 per cent Mo) were produced.

Saving in Transportation.—A considerable saving in transportation has been effected by fertilizer manufacturers by loading railway cars up to capacity, and then a little more. A freight car is not like a truck for heavy material to be pulled by a team of horses. The engine can pull it. And every car counts.

Synopsis of Recent Metallurgical and Chemical Literature

Log of An Electric Furnace.—E. A. SUVERKROP presents a description of the manufacture of electric-furnace tool steel as practised at the Watervliet works of the Ludlum Steel Company in the American Machinist of Feb. 28, 1918. Of considerable metallurgical interest is the following log covering one heat of an arc-furnace (style and capacity not given, but possibly making about seven tons per heat):

4:55—Charge started with furnace full of cold metal. Lime and mill scale added at start for dephosphorizing slag. Balance of charge added when the melting of the scrap provided sufficient room. The temperature of the melting stage is kept as low as possible to effectively remove the phosphorus.

9:16—Metal boiling; slag thinned by two shovels of silica. Slag rabbled.

9:24—Metal quiet and sampled for analysis. Slag black.

9:30—Lime added to slag to thicken, preparatory to removal.

9:35—Current off; black dephosphorizing slag raked off.

| | Analysis of Melt | Analysis Desired |
|------------------|------------------|------------------|
| Carbon | 0.59 | 0.95 |
| Silicon | | 0.15 |
| Manganese | | 0.20 |
| Chromium | 0.37 | 0.45 |
| Phosphorus | 0.018 | 0.015 |
| Sulphur | 0.025 | 0.012 |

9:39—Ten shovels of a mixture of lime, fluorspar and sand added to make second slag.

9:45—Slag sampled—was thin, showing some unfused lime.

9:53—Slag sampled—smooth and thin, color gray, condition reducing.

9:54—Metal sampled for analysis. Current off.

10:00—Slag temperature, 2573 deg. F.

10:02—Current on.

10:03—Five shovels of dope added to reinforce desulphurizing action of slag.

10:08—Slag sampled, condition good, as noted at 9:53.

10:10—Lime added to thicken slag preparatory to removal.

10:12—Current off.

10:14—Slag very thick and easily raked off. Metal 2570 deg. F.

10:20—Weighed amount of carbon added to metal.

10:22—Furnace doors luted to exclude air.

10:40—Furnace unsealed. Metal 2596 deg. F. Third slag made of seven shovels of mixture of lime, fluorspar and sand.

10:52—Slag sampled, color gray and in excellent condition. Alloy added to bath.

10:59—Slag shows slight greenish tint, due to chromium.

11:02—Sample of slag and metal sent to laboratory for analysis. Slag temperature 2662 deg. F.

11:05—Current off. Green color in slag fading.

11:08—Slag 2652 deg. F. Current off waiting analysis. Ladles being preheated.

11:32—Slag too thin, four shovels lime added.

11:35—Slag in excellent condition, brownish gray color.

11:42—Additions of alloys to correct analysis made.

11:52—Test bar of metal forged to determine mechanical condition.

11:53—Metal agitated to perfect mixture.

11:55—Slag sampled, small quantity of lime added to bring it to exactly neutral condition. Temperature 2650 deg. F.

11:58—Small amount of ferro-silicon added to melt. Surface of melt quiet.

12:06—Additions of fluospar and silica to slag. Temperature 2690 deg. F. Current off.

As the metal was poured into the ladle, the temperature was taken as 2641 deg. F. and had dropped to 2640 when the first ingot was poured. Seventeen ingots were poured, each taking about 35 seconds. Temperature of the last ingot 2550 deg. F. The second ladle of metal came from the furnace at 2618 deg. F., the first ingot was poured at 2600, and, after thirty-five smaller ingots, the last was poured at 2575 deg. F.

Developments in By-Product Coking.—A paper on this subject was read before the December meeting of the Institution of Civil Engineers (British) by GEORGE B. WALKER. The author stated that the aim in recent designs was to secure better equalization of heat in all parts of the oven walls, to equalize the pressure between retort and heating flues, to reduce the time of coking, to facilitate inspection and regulation of all parts of the oven, to increase the yield of ammonia and benzol, and to economize in the use of gas for heating the ovens. The so-called "direct" process for the recovery of ammonium sulphate was shown to be more advantageous than the older practices, since the recovery of the nitrogen is performed without the use of condensers, coolers or scrubbers, consequently eliminating the need of a large quantity of cooling water with the attendant loss of heat, and being therefore independent of the temperature or the season. The plant is said to be no more expensive to construct or maintain than that for the scrubber process, and no noxious effluent is produced whether or not benzol is recovered.

The advantage of regenerative working is clearly brought out by the following generalizations: Assuming a battery of 50 modern by-product ovens, each having a capacity of 10 tons damp coal and carbonizing five charges per week, 2750 tons of coal (containing 30 per cent volatile and yielding at least 10,000 cu. ft. gas per tons) would be coked in that time. Running with waste heat boilers and no regenerators the exit gases at about 800 deg. C. should evaporate 500 gallons of water per hour, which would produce steam for non-condensing engines producing approximately 1200 hp. In addition there would be a small amount of surplus gas available. If, however, the ovens were equipped with regenerative checkerwork, the consequent use of highly heated air for combustion in the oven-flues reduces the consumption of scrubbed gas at this point sometimes to a figure as low as 40 per cent of that evolved. Supposing, however, that only 40 per cent of the gas was available for use in internal combustion engines, 2180 hp. could be produced therefrom, reckoning 30 feet of gas per horse-power-hour.

Steel Turnings and the Electric Furnace.—A note on this subject is given in the *Iron and Coal Trade Review* (London) for Dec. 21, 1917, by JOHN A. HOLDEN. He says that a few years ago steel turnings were not in very much demand, and good, clean turnings could be bought for 30s. per ton. The price to-day for the same metal is about £4 per ton, a figure which would, no doubt, have been exceeded but for the intervention of the Ministry of Munitions. He says the reason for this appreciation is not difficult to seek. The raw material for the manufacture of electric steel in the arc type of furnace consists almost entirely of turnings. The writer refers to those furnaces which are worked with cold stock. Incidentally, it may be added, in England very few furnaces are worked with liquid charges.

Fifty 3-ton electric furnaces would consume annually 150,000 tons of steel turnings. In addition, turnings often form a portion of a Siemens charge, and sometimes they are used in blast-furnace charges. For producing electric carbon tool steel mild-steel turnings from shells are in much demand. Nickel-steel turnings are used for the manufacture of nickel-steel ingots. With a suitable grade of scrap no addition of nickel may be required, because in any type of electric furnace there is no oxidation of nickel.

Similarly, nickel-chrome-steel turnings may be profitably converted into nickel-chrome-steel ingots. In acid-lined furnaces there is little or no loss of chromium; in fact, the reactions in this furnace are comparable to those of the crucible process. In basic-lined furnaces chromium may be retained or eliminated. In the former case the phosphorus would not be so completely oxidized, but nevertheless it would be confined to safe limits. It follows that for the cheap production of alloy steels, such as nickel and nickel-chromium, scrap turnings containing the necessary elements should always be used.

From an economic point of view, it is undesirable that alloy-steel turnings should be used in charges where the alloying elements are not necessary or desirable. Many engineering establishments do not keep all these varieties of scrap separate. They may religiously look after high-speed steel, but other alloy steels are mixed with plain carbon-steel turnings. In addition, the heaps of turnings sometimes become a dump for waste paper, or even worse refuse, etc. In those shops where the amount of scrap produced is very small, it may not be economically possible to separate the different varieties. Unfortunately, there are works producing weekly as much as 100 tons of turnings consisting of only two varieties, yet they do not trouble to keep them separate.

One example will suffice to illustrate the loss when nickel steel is used in charges where nickel is not necessary. Fifty tons of 3 per cent nickel steel scrap contain £300 worth of nickel. Taking 50 tons as a weekly average, it represents potentially £15,000 per annum. Whilst every electric steel smelter desires short heavy turnings, it has been found practicable to crush the lighter turnings and obtain results equal to those obtained by the use of the more expensive and weighty turnings.

Action of Caustic Liquors on Steel Plates.—Two interesting articles have recently appeared in the *Chemical Trade Journal and Chemical Engineer* (London) on the action of caustic liquors on steel plates. The subject

is a very important one. In the first article (Dec. 22, 1917), C. E. STROMEYER discusses tests which he made with the idea of determining the effect of stresses and whether they were the cause of cracks. He experienced great difficulty in maintaining the test pieces in a strained condition. Pieces strained before being acted on by caustic would have no stress afterward. He states that this experience was very disconcerting, and may account for the results obtained by Professors Heyn of England and Parr of the United States who could detect no effect due to straining. The experience is, however, not without practical interest, as it points to a possibility that caustic liquor may cause a slacking back of rivets and caulked edges and lead to leakages. He thinks it will be no easy matter to devise tests which will maintain the samples in a strained condition, for in his experiments the stress had to be produced by the elasticity of the material, and if that fails the stress disappears. The case is different in a boiler, for there the stress is due to the boiler pressure, and though the caustic may relieve some stresses, as is shown by the flying off of rivet heads, the average stresses will be maintained, and some local stresses may even be increased.

Professor Heyn has published nothing on this subject, but wrote that he could not confirm the writer's results. Professor Parr, in the 94th Bulletin of the Illinois University, deals with the following points. He notes a change of electric potential if steel is immersed in caustic. The tensile tests showed a reduction of tenacity of about 30 per cent after treatment, but this reduction was not influenced by change of density of the liquor. The elongation improved about 10 per cent. The samples which were stressed during exposure behaved in the same way. Judging by his experiments and the description of Professor Parr's, the author thinks it doubtful whether his samples were really stressed while exposed. He also submitted some of his exposed samples to alternate (fatigue) stresses, and found about 20 per cent reduction in the number of reversals of stress before fracture occurred. The impact test results were about 10 per cent lower for the treated than for the untreated specimens. Professor Parr's most important results are his determination of the hydrogen which is absorbed by steel and iron when immersed in caustic soda, and, as it is well known that hydrogen makes certain steels very brittle, these determinations should explain the brittleness. However, as already stated, this brittleness seems to be produced only if the steel is stressed during exposure, but details of the conditions have not yet been determined. In the writer's experiments a change of density could not be detected.

The second article by ERNEST WORSLEY (Jan. 26, 1918) deals especially with vacuum evaporators. The author does not believe that the action of the caustic on the metal during tension is the sole cause of breakage, and cites numerous examples to prove this. He says the breakage occurs with other liquors, such as glue, and that the only sure way of preventing the breakage altogether is to use Mannesmann tubes. These tubes will not, however, resist corrosion and there appears to be some relation between the breaking of tubes and the internal wear, as tubes which break do not wear and vice versa. Another curious feature about the breaking of the tube is that the fracture always occurs at the

ends—never in the middle portion. The author concludes from the examples which he cites from plants in actual operation—that the breakage of tubes in vacuum evaporators is not due to caustic liquor any more than to any other liquid and can be prevented only by the proper selection of tubes, i.e., tubes made of steel, which can be annealed without any sign of "shortness."

The Groch Flotation Machine.—A new flotation machine is described in the Canadian Mining Institute Bulletin, March, 1918, by F. O. GROCH and W. E. SIMPSON. As is seen by the sketch, the chief distinctive feature is a centrifugal impeller which has hollow hubs and is subdivided horizontally by a metal disc so as to

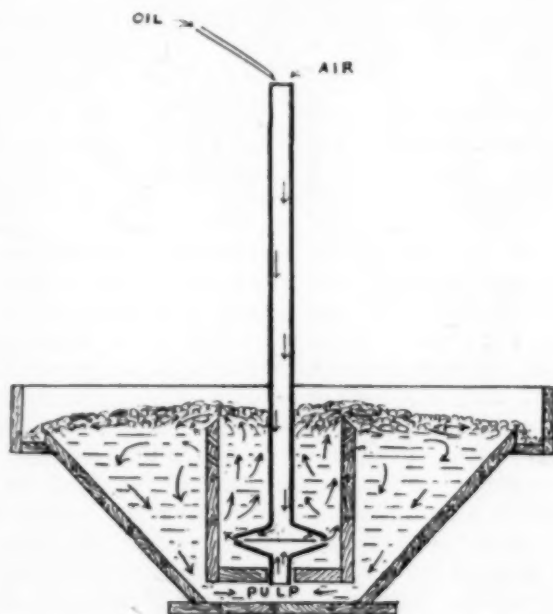


DIAGRAM ILLUSTRATING ACTION OF THE GROCH FLOTATION MACHINE

operate after the manner of a pair of centrifugal pumps. The pulp enters the treatment zone by being sucked up into the lower "runner" and ejected centrifugally at the periphery in a horizontal plane, where it must rise through a similar sheet of air and atomized oil (The system therefore gives most intimate contact between the ore particles and the finely divided air and oil.) The vacuum created at the discharge amounts to 2.75 inches of mercury at 450 r.p.m. and 6 inches at 750 r.p.m.

This machine eliminates the disadvantage associated with machines using the blade type of impeller of having to beat the air into the pulp by the creation of a deep vortex. Consequently the power consumption is quite low, a standard machine of six impellers with a capacity of about 55 tons of ore per day consumes 7.5 hp. The machine has been used on silver and molybdenite ores in the Cobalt region with marked success.

Basalt Lava for Filtration Purposes.—An article in Schweizerische Bauzeitung, Jan. 5, 1918, abstracted from Zeit. der Verein Deutscher Ingenieure, states that experiments with finely crushed lava from extinct volcanoes in Central Germany have shown that this material is an excellent substitute for kieselguhr in the filtration of drinking water. Drs. Hambloch and Morziol take the lava deposits, grind them to a finely gran-

ulated condition, and wash them in a solution of sodium carbonate or in diluted hydrochloric acid. Roasting the granulated product preparatory to washing increases its cleansing qualities as well as its plasticity.

Recovery of Ammonia from Gas.—In the *Gas Record* for Feb. 27, 1918, Dr. JOHN S. UNGER, in an article on this subject, states that there are many good-sized coal-gas works in the country in which no income is derived from ammonia recovery. He says it should be the ambition of every manager of a coal-gas works, carbonizing 3000 tons of coal per year and over, to obtain an ammonia still and make concentrated gas liquor in small works, sulphate and aqua ammonia in larger works. He emphasizes particularly the advisability of using a modern high-grade still with adequate controlling devices. He describes a plant in Illinois which produced 36,511 lb. of concentrated ammonia in 1917 from 8166 tons of coal, or a yield of 4.5 lb. per ton. One year's operation paid for the cost of installation. When using two-thirds Kentucky and one-third Illinois coal the recovery is 5.25 lb. ammonia per ton of coal. It is estimated that we will need 150,000,000 lb. of ammonia this year for munitions and 40,000,000 for cold storage. Our production last year was 130,000,000 and we will have a severe shortage unless all sources are producing.

Recent Metallurgical and Chemical Patents

Dyes and Intermediates

Production of Beta-Naphthol Benzoate.—GUSTAV BLIEBERGER of New York patents a process which he assigns to the Anthony-Hammond Chemical Works of New York. He produces benzoyl chloride by heating together benzoic acid and phosphorus trichloride or penta chloride. The benzoyl chloride is then dropped on molten beta naphthol and any benzoyl chloride evaporated is caught in a reflex condenser. The beta naphthol benzoate thus formed is dissolved in alcohol and recrystallized. (1,254,970, Jan. 29, 1918.)

Vegetable Dye.—ISIDOR KITSEE of Philadelphia, Pa., patents a fast dye made by adding two metallic compounds to logwood. Chloride of zinc, copper ammonium chloride, chloride of tin, hydrochloric acid, and other compounds are added according to the color desired. (1,254,914, Jan. 29, 1918.)

Benzene-Naphthalene Dyes.—A patent issued to HEINRICH GRÜNHAGEN of Germany refers to the manufacture of dyes of the benzene-naphthalene acridin series. The dyes are made by heating a formyl derivative of a beta naphthylamine such as formyl-2-naphthylamine and a salt of a meta-diamine of the benzene series such as amino-dimethylaniline hydrochloride. The melt is dissolved in water and the dye precipitated with salt and zinc chloride. (1,255,740, Feb. 5, 1918.) Another patent issued to the above refers to halogenated dyes of the acridine series obtained by heating a halogen derivative of a formyl-meta-diamine of the benzene series with a salt of an aromatic meta-diamine. (1,255,739, Feb. 5, 1918.)

Apparatus

Evaporation Apparatus.—Dr. EDWARD HART of Easton, Pa., patents an evaporating apparatus particularly applicable to acids. A series of horizontal cylindrical tubes are placed in cascade as shown in Fig. 1.

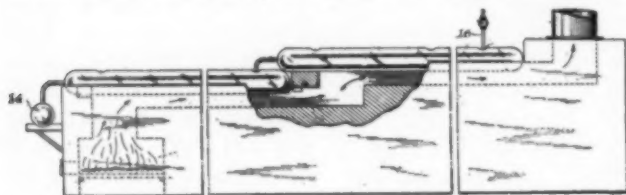


FIG. 1. SIDE VIEW OF HART EVAPORATOR

The tubes are either made of or lined with glass. The more or less dilute liquid enters the uppermost evaporators at a rate somewhat faster than it can be evaporated. The excess escapes into the next lower evaporators of the cascade and is finally delivered to the manifold 14, whence it is discharged by a pipe from 14 into any suitable receptacle, not shown. The evaporators being elongated, the liquid entering at one end of an evaporator has ample opportunity to mix thoroughly with the liquid (more or less concentrated) in the evaporator, before the overflow pipe at the opposite end is reached. The thorough mixing is important, and is due to several factors. First, the liquid entering any given evaporator is somewhat cooler than the liquid therein, thus causing a tendency of the incoming liquid to sink. Second, the convection currents are active and rapid because of the heating of the bottoms and the cooling effect of evaporation at the surface. Third, when boiling is permitted the ebullition agitates the liquid more or less strongly. The result is that if the supply by way of the pipes 16 is properly regulated the liquid in each evaporator is thoroughly homogeneous by the time it reaches the outlet pipe, so that the liquid escaping is no more and no less concentrated than the liquid remaining.

The evaporators and the receiving manifold at the end are simply laid on their supports and the discharge orifices of the supply and outlet pipes are free, so that any of the several vessels can be easily removed and replaced. While the total quantity of liquid in the system may be quite large, the quantity in any particular vessel is thus not the serious matter that it is in the case of a large receptacle, and replacement of a broken part is correspondingly cheaper and easier. If desired a dome may be arranged over the apparatus to collect the escaping vapors. (1,254,689, Jan. 29, 1918.)

Miscellaneous Processes and Products

Chlorine and Sodium Sulphate.—HERMAN B. KIPPER of New York City patents a catalytic process of producing chlorine and sodium sulphate. It is claimed that this process is much cheaper than the electrolytic or manganese chloride process. The process is based on the action of sulphur dioxide, water and oxygen, on sodium chloride. A catalyst such as ferric oxide is used in order to prevent the formation of hydrochloric acid. The temperature used is 400 to 600 deg. C. The process is carried out in a closed horizontal revolving iron cylinder similar to a roasting cylinder. There is an inlet tube at one end and an outlet at the other.

Powdered sodium chloride is introduced through a hopper at the inlet and the catalyst is made up in the form of large balls so that they travel through the cylinder and are easily separated from the sodium sulphate formed. These balls are made from ground ferric oxide and sodium sulphate. The sulphur dioxide is introduced through the same tube as the salt. A flange on the inside of the drum raises the sodium sulphate formed and discharges it at the discharge end. The drum is continuously rotated. (1,255,020, Jan. 29, 1918.)

Drying Oils.—FELIX C. THIELE of Coffeyville, Kan., assigns a patent on drying oil manufacture to The Cudahy Refining Company of Coffeyville, Kan. Kerosene is treated with a halogen such as chlorine, then acidulated with acetic acid and treated with a metal such as zinc. (1,254,866, Jan. 29, 1918.)

Distillation of Coal.—CHARLES FOXWELL of Baltimore proposes to add to coal before distillation a substance which will not give up its entire water until a temperature has been reached at which all the desired products are given off. This is preferably accomplished by treating the combustible materials before they are distilled, with a water solution of calcium chloride and an oxygen-bearing compound of boron. This will retard combustion owing to the water being slowly expelled from the added solution, some of the water being retained even until after attainment of a temperature sufficient to volatilize all of the distillate sought after. In other words, by the time all the water has been expelled from the chemical compound the by-products will have been distilled over, and the fire may thereafter be regulated with respect to the product, for example coke, to be obtained from the base of the combustible material. Commercial borax ($\text{Na}_2\text{B}_4\text{O}_{10}$) serves well for the boron compound, and this being dissolved in water, together with calcium chloride, in the proportions of, say, 382 lb. of commercial borax to 918 lb. of calcium chloride of 72 per cent purity, will make the chlorine and boron molecularly equivalent. In practice, the material is sprinkled with the solution in sufficient quantity, the material being thoroughly mixed or turned over during the treatment. When so treated, the material is ready to be distilled. (1,255,593, Feb. 5, 1918.)

Electric Furnaces

Induction Furnaces.—J. R. WYATT of Philadelphia, Pa., patents a variety of forms of induction furnaces (assigned to Ajax Metal Company) consisting of a large pool of molten metal heated by the circulation of hot metal driven through attached channels. These channels form the secondary circuits of enclosing transformers, and may be placed at various angles and in various combinations to the sides of the main pool or below it, and as many in number as required by the construction or by the number of phases of current used. As is shown in Figs. 2 and 3, which illustrate the simplest design, the secondary channels (36 and 37) are straight and intersect at the outer end in an acute angle (35). The length, width and height of the channel will be dictated by the total resistance desired in the secondary—using a given melt—the dimensions of the pool, and the location of the channels. The induced current in opposite directions in adjacent channels containing a molten conductor results in a motor

effect tending to separate the conductor, which face varies as the product of the currents in the two conductors and inversely as the distance between the parts of the molten metal affected. Consequently the motor effect is intensified at any angle in the conductor, increasing with the sharpness of the angle until counterbalanced by increase in friction at such a point. Joule effect is not very effective in comparison. A narrow channel intensifies the

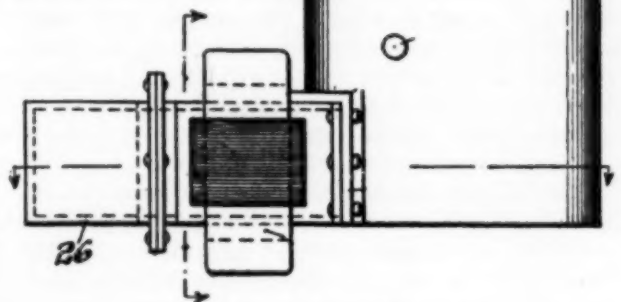


FIG. 2. SIDE ELEVATION

effect at the corner, but increases fluid friction, while a high channel receives a large transformer flux. In a brass furnace having a channel beneath the pool, a pouring heat of over 200 pounds, and a secondary current of 7000 or 8000 amperes, excellent results were had with a channel 18 inches long by 3 inches high by $\frac{5}{8}$ inch wide.

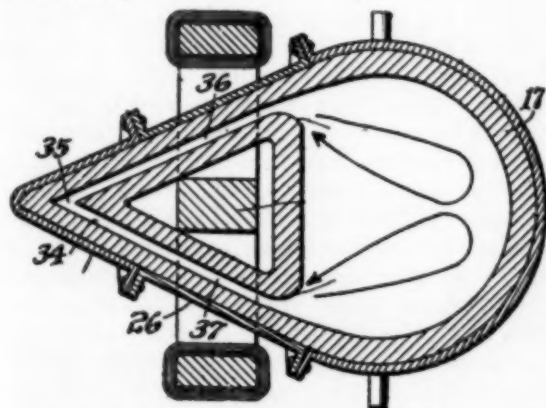


FIG. 3. SECTIONAL PLAN 2-2

In operation it is quite desirable to pour the initial charge from another furnace. The current is then turned on and heating of that charge and material added from time to time is effected by the secondary current. The hotter metal is driven out along the outer sides of channels 36 and 37, and is replaced by a flow of cooler metal from the pool passing along the inner sides of the same channel sections, heating the pool by the additional heat of the hotter metal withdrawn and stirring the pool by the flow, with a resultant intermingling of the hotter metal with that of the pool and gradual and nearly uniform increase of temperature throughout the pool. A narrow stream of hot metal ejected at considerable speed is much more effective than the same quantity delivered in a larger stream at a lower rate, since the stirring effect and immediate

distribution obtained by the higher speed reduces the amount of mixing which must be accomplished by the slower Joule effect.

The casing 26 may be jointed at several points and separated by asbestos insulation to reduce the secondary current in the casing; or the furnace lining 17 and 34 may be itself a conductor of the first class in case a low-melting alloy of high resistivity is to be melted. In the latter case the furnace can be entirely drained at each cast; in the former, it must not be tilted to such a high angle as to break the molten secondary. The rounding of the junction (42) between channel and pool is necessary to reduce motor effect at these points. The furnace is particularly adapted for remelting chips or turnings of brass and other alloys. It is necessary to superheat these melts several hundred degrees above their melting points in order to pour good castings, in which case the vaporization of one or more components of the charge is usually quite serious. In this furnace any metal vaporized in the secondary channels is condensed before reaching the surface of the pool. (1,235,628, 1,235,629 and 1,235,630; Aug. 7, 1917).

Electrolytic Processes

Anode Suspension.—F. L. ANTISELL of Perth Amboy, N. J., points out the following difficulties in the manufacture and use of anodes with cast lugs: Thin lugs and anodes are hard to cast owing to chilling of the metal in the mold, even though it is desirable to pack as many into one tank as possible. Cast lugs are often warped, causing anodes to hang out of plumb and rough, causing poor electrical contact where they rest on the sides of the tank. Lugs are liable to damage in shipping, and cause a large amount of unelectrolysed scrap. They cannot be passed through rolls to smooth out irregularities. These objections hold in general anodes hung from hooks or links from rods, with the additional objection that one or two additional contacts are introduced, each consuming about 10 per cent of the total power used in refining.

His improved suspension is illustrated in Fig. 4,

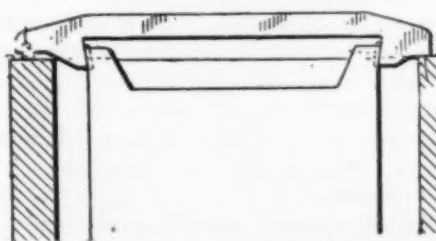


FIG. 4. METHOD OF ANODE SUSPENSION

where the suspension bar has V-shaped knife edges engaging in inclined slots in the edge of the anode. Good electrical contact at this point is insured by wedge action, giving up to four times the pressure of the weight of the anode, noting that by actual experience it has been found that within the range of current densities and voltages prevalent in copper refineries the reduction in resistance of the contact is about proportional to the pressure of contact. Using a suspension bar of refined copper has additional effect in reducing the resistance of the combination, which is claimed to reduce the contact loss from 10 per cent to $2\frac{1}{2}$ per cent or less. (1,250,757, Dec. 18, 1917.)

calculate the percentage of the total caustic that will be recovered by a given number of thickeners.

Fig. 2 shows a conventional flow-sheet of a continuous causticizing plant based on the assumptions made

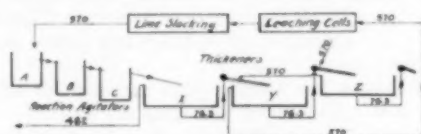


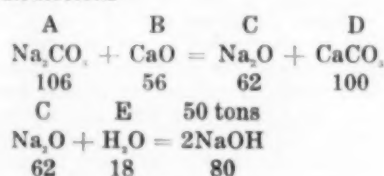
FIG. 2. CONTINUOUS COUNTER-CURRENT CAUSTICIZING PLANT

below. The figures given on the flow-sheet represent the tons of water flowing into and out of each unit.

Assumptions

- Plant to produce 50 tons NaOH per 24 hours
- Solution to be approximately 9.4 per cent NaOH (14 deg. Be.)
- Black-ash leach-liquor to be recausticized
- Agitation period 2 hours
- 50 per cent H₂O in thickener underflows
- Yield to be 93 per cent
- Na₂CO₃ ratio to be 10:6

Calculations



$$C : 62 = 50 : 80$$

$$C = 38.75 \text{ tons theoretical Na}_2\text{O} = 93 \text{ per cent}$$

$$F = 41.65 \text{ tons required Na}_2\text{O} = 100 \text{ per cent}$$

$$A : 106 = 41.65 : 62$$

$$A = 71.25 \text{ tons Na}_2\text{CO}_3 \text{ required}$$

$$71.25 : B = 10 : 6$$

$$B = 42.75 \text{ tons CaO required}$$

$$D : 100 = 42.75 : 56$$

$$D = 76.3 \text{ tons lime mud produced}$$

$$E : 18 = 50 : 80$$

$$\text{Water : solid} = 1 : 1$$

$$E = 11.7 \text{ tons water required for reaction.}$$

$$76.3 \text{ tons water lost with lime mud.}$$

$$50 \text{ tons} = 9.4\%$$

$$532 \text{ tons} = 100\%$$

$$532 - 50 = 482.0 \text{ tons water with finished caustic liquor.}$$

$$570.0 \text{ tons total water required.}$$

Let X, Y and Z equal the value of the caustic liquor in each thickener in lb. of NaOH per ton of water.

By equating the expression for the amount of NaOH entering and leaving each thickener, the following simultaneous equations are obtained:

$$(1) 582X + 76.3X = 570Y + 100,000 \text{ lb. NaOH}$$

$$(2) 570Y + 76.3Y = 76.3X + 570Z$$

$$(3) 570Z + 76.3Z = 76.3Y$$

Or

$$(1) 558.3X = 570Y + 100,000$$

$$(2) 646.3Y = 76.3X + 570Z$$

$$(3) 646.3Z = 76.3Y$$

Solving

(3)

$$646.3Z = 76.3Y$$

$$Z = .118Y$$

Substituting value of Z in terms of Y in (2)

$$646.3Y = 76.3X + 570(.118Y)$$

$$579 Y = 76.3X$$

$$Y = .1317X$$

Substituting value of Y in terms of X in (1)

$$558.3X = 570(.1317X) + 100,000$$

$$483.2X = 100,000$$

$$X = 207 \text{ lb.}$$

$$Y = 27.5 \text{ lb.}$$

$$Z = 3.28 \text{ lb.}$$

The 482 tons of water going to storage with the finished liquor will carry 207 lb. NaOH per ton, or..... 99,751 lb.
The 76.3 tons of water going to waste with the lime mud will carry 3.28 lb. NaOH per ton, or..... 250 lb.

Total..... 100,001 lb.

Error due to neglect of decimals..... 1 lb.

Washing efficiency or recovery, 99.75 per cent.

DERIVATION OF ABOVE EQUATION

The total amount of NaOH leaving each thickener per 24 hours must equal the total amount entering it. Reference to the flow-sheet shows that 482 tons of water carrying X lb. of NaOH per ton leave thickener X and go to storage; 76.3 tons of water carrying X lb. NaOH per ton leave with the lime mud and enter thickener Y. Entering thickener X we have 570 tons of water carrying Y lb. NaOH per ton plus 50 tons of NaOH produced in the agitators. Entering thickener Y we have 76.3 tons of water with the lime mud from thickener X carrying X lb. NaOH per ton and 570 tons of water in the overflow from thickener Z carrying Z lb. NaOH per ton. Leaving thickener Y we have 570 tons of water carrying Y lb. NaOH per ton in the overflow, 76.3 tons of water carrying Y lb. NaOH per ton in the underflow. Entering thickener Z we have 76.3 tons of water in the underflow from thickener Y, carrying Y lb. NaOH per ton. The water entering thickener Z carries no value in NaOH, and hence 76.3Y is the only NaOH entering thickener Z. Leaving thickener Z we have 570 tons in the overflow carrying Z lb. per ton, and 76.3 tons in the underflow carrying Z lb. per ton.

Recent estimates made by the Dorr Company based on producing about 40 tons per day of caustic soda show that the total production cost exclusive of the cost of raw materials, is approximately 47 cents per ton of 100 per cent NaOH, with labor at 30 cents per hour and power at 2 cents per kw.-hr. This system of causticizing has been adopted by the Du Pont Engineering Company for a plant to produce 39 tons of caustic soda per day, which is to be built in connection with a plant now under construction for the United States government, and also by the Air Nitrates Corporation in connection with the plant they are building for the government at Muscle Shoals, Ala.

U. S. Trade with New Zealand.—The imports from American sources to New Zealand in 1915 were valued at \$12,500,000, in 1916 at \$19,000,000 and in the first six months of 1917 were \$9,000,000. Paints and varnishes form an important part of the imports, while microscopes have also been sold in increased numbers. Petroleum products have also increased.

Personal

MR. EARL ADAMS, lately sales manager, powdered coal department, Bonnot Company, Canton, Ohio, and for some years in charge of gas producer work for The Power & Mining Machinery Co., has accepted a position as sales engineer for the Smith Gas Engineering Company and will shortly be located at Dayton, Ohio, where the new plant of the Smith Gas Engineering Company is nearing completion. A. B. MORRISON, JR., has also recently accepted a position with the company as sales engineer. Mr. Morrison was formerly with the Fort Wayne Electric Works and the Rathbun-Jones Engineering Company, and more recently with the John H. McGowan Company as Philadelphia representative.

MR. WILMER C. DUTTON of the Tolhurst Machine Works, Troy, N. Y., has been elected vice-president of the company and will be located at the New York office, at 111 Broadway.

DR. F. A. FAHRENWALD, consulting mining engineer and metallurgist, of Cleveland, will be in the West on professional business from about March 25 to May 10: the first two weeks in New Mexico and Arizona; the next two weeks in California and Nevada, and the remainder of the period in the Northwest.

MR. WILLIAM J. GROSS, formerly with the Sherwin-Williams Co., at Chicago, is now chief chemist of the Nordyke & Marmon Co., Inc., of Indianapolis, large manufacturers of automobiles and machinery. The Nordyke & Marmon Co. is doing extensive war work for the government.

MR. ROBERT M. KEENEY, manager of the Ferro Alloy Company, Denver, Col., is acting as consulting engineer to the Anaconda Copper Mining Company on the manufacture of ferromanganese which the company is planning to start. He is in charge of construction and operation, but retains his connection with the Ferro Alloy Co., spending ten days per month in Great Falls.

DR. F. G. KEYES, formerly chief engineer of the Cooper Hewitt Electric Company, Hoboken, N. J., has received the commission of captain in the chemical section of the national army.

MESSRS. OSTENBERG & CHRISTIANSEN, consulting chemical engineers of San Jose, Cal., have both taken up war work. Dr. Ostenberg has entered the Naval Flying Station at San Diego and Dr. Christiansen is a lieutenant on the medical staff of the navy.

MR. CURTIS PIGOTT, assistant superintendent of the Midvale plant of the United States Smelting, Refining and Mining Company, has resigned to become superintendent of the Herculaneum plant of the St. Joseph Lead Company, vice WILLIAM A. SMITH, resigned. Mr. Pigott was formerly connected with the Helena and Murray plants of the American Smelting and Refining Company, and is succeeded at Midvale by ROBERT WALLACE, metallurgist.

MESSRS. J. L. SCHOELLKOPF, former president, and C. F. Hugo Schoellkopf, third vice-president, have withdrawn from the active management in the National Aniline & Chemical Co. They will continue as directors and stockholders. William J. Matheson was elected president. He is a director of the General Chemical Company, which is largely interested in the National Aniline Company. Dr. L. C. Jones of the Solvay Process Co. succeeds C. P. H. Schoellkopf as vice-president.

MR. R. C. SHUEY has been appointed assistant superintendent of Armour's Soap Works.

DR. JULIUS STEIGLITZ, Mr. A. V. H. MORY and Mr. WILLIAM HOSKINS were the delegates of the American Chemical Society to the Congress of National Service, which was held in Chicago, February 21, 22 and 23. The congress was under the auspices of the National Security League.

MR. W. L. TANNER, chief engineer of the Washoe plant of the Anaconda Copper Mining Company, has been transferred to Butte, where he will act as chief engineer of all the A. C. M. Co. operations in Montana.

Current Market Reports

Non-Ferrous Metal Market

Tuesday, March 26.—The markets for the most part have been quiet. Copper has been in good demand and tin continues scarce, with considerable demand. There has been plenty of lead offered and spelter has been considerably depressed in price.

Copper.—There has been a good demand for copper from consumers not engaged on government orders. Producers are not making large offerings, as a considerable part of their production is tied up until May and June. Prices remain as fixed by the government at 23.50 cents, producers' price, and 24.67½ cents, jobbers' price. Smelter production in January and February averaged 185,000,000 lb. monthly. Gains are expected in March and April.

Tin.—The tin situation continues very difficult. Straits tin is practically off the market, and such tin as can be brought brings fancy prices. As high as 85.50 cents has been paid for 99 per cent tin. Future Banca tin is quoted at 78.50 cents for April delivery. Chinese No. 1 is quoted at 77 cents for April delivery. There is reported to be 6300 tons afloat bound for this country, but arrivals have been slow and in small amounts for some time.

Lead.—Freer offerings have characterized the lead market during the past ten days. The trust price continues at 7¼c., New York. Independents asked 7¼c. to 7½c. A strike at the St. Joseph Lead Co.'s smelter at Herculaneum, Mo., on March 16, continued unsettled at the time of writing. There seems to be plenty of lead to take care of all requirements, but the demand continues strong and no impairment of the position of the market seems imminent.

Spelter.—In contrast to the other markets the spelter market has been dull and weak. Producers of spelter have had troubles of their own for such a long time due to overproduction that they would doubtless welcome price fixing by the government. Most producers are declining to quote at present prices, which are 7.30 to 7.55, New York, and 7.12½ to 7.25, St. Louis. The low prices may effect a decrease in production due to shutting down of some plants.

OTHER METALS

| | |
|--|---------------|
| Aluminium, lb., 98-99 per cent, virgin, Gov't price... | .321 |
| Bismuth, lb. | 2.50-2.75 |
| Cadmium, lb. | 1.50 |
| Nickel, electrolytic, lb. | 55.50 |
| Silver, oz. | .92½ |
| Platinum, oz. | 108.00 |
| Palladium, oz. | 135.00-137.00 |
| Cobalt, lb. | 3.25-3.50 |
| Magnesium, lb. | 2.00 |
| Quicksilver, Cal. | 120.00 |
| Quicksilver, Mexican. | 115.00 |

The Iron and Steel Market

Shipments of finished steel products by mills continue to increase, but rather slowly. Traffic conditions on the railroads are still regarded as the limiting influence, but as time passes there is, almost insensibly, a change in the appearance of things, whereby it becomes doubtful whether this is the sole limiting influence. There is really a decided lack of pressure for deliveries on the part of some customers, and there is ground for suspicion that if shipping conditions enabled the mills to ship all their products at capacity they would be met by some customers with requests to curtail shipments. It is natural for mills to endeavor to place the best interpretation possible upon conditions, and to ascribe the curtailment in shipments wholly to traffic conditions is no more than natural, even though there may be other influences.

An outstanding feature of the market situation is that for the great majority of products there is practically no demand except that arising from the war. This, however, is not as indicative an item as might be supposed, for there is good reason to believe that the mills have on their books orders and contracts involving more than 12,000,000 tons of commercial steel, entirely apart from Government orders and orders from those who have Government orders to fill. That is a very large tonnage even for normal times, and when so much material is due to customers it is somewhat difficult to imagine who would be the customers who would

be anxious to buy large additional tonnages. In this connection it is important to bear in mind that owing to uncertainties of business as well as uncertainties of delivery, owing to the priority that must be given to war work, it is not the disposition of the trade, either buyers or sellers, to make engagements far ahead, as they frequently do in peace times. It was generally predicted, when the system of set Government prices was inaugurated late last September, that the trend would be strongly toward a clearing off of order books, the ultimate condition to be approached being one of almost hand-to-mouth buying in the case of everything except war material.

The genuineness of the contract business on books, how certain or uncertain it is to lead to specifications and actual shipping instructions, is very much in doubt. After an excited and advancing market the mills are always left with a large volume of contract business, not all of which is carried out, and at the present time the uncertainties are greater than is usual in such cases.

WAR REQUIREMENTS

Indications as to the volume of war steel requirements are becoming somewhat more definite. The shipbuilding work is gradually getting into better form, and a rate of building 500,000 deadweight tonnage a month may be reached in the early fall, involving the consumption, altogether, of about 250,000 gross tons of steel per month, at least one-half of this being in the form of sheared plates. Even a much larger consumption would not tax the plate mills, however. In 1916 their output of sheared plates, $\frac{1}{4}$ -inch and heavier, averaged a trifle more than 150,000 tons a month, and capacity is, or soon will be, close to 300,000 tons a month.

The car buying program, which will be arranged largely by the Railroad Administration, although the orders will be placed chiefly by individual roads, is being gotten into shape, with prospects that very nearly the full car building capacity of the country will be engaged. This, with locomotive building, may for a time absorb 300,000 to 400,000 tons of rolled steel, chiefly in the form of sheared and universal plates and structural shapes. An effort is being made to use universal plates to the fullest extent possible.

The shell steel program involves 2,500,000 tons for the second half of this year, against 1,500,000 tons ordered for delivery to the middle of next June, a small portion of the tonnage having been shipped in the closing months of last year.

At the moment there are large requirements for various construction items in connection with the war, including large tonnages of structural shapes and concrete reinforcing bars for docks and warehouses on both sides of the Atlantic, the object being to serve to the utmost the convenience of the ocean vessels, as well as the "port to front" road of the A. E. F. in France.

IRON AND STEEL PRICES

At this writing there is no official information as to the decision of the War Industries Board as to what iron and steel prices shall rule after March 31, or how long the new prices, or the reaffirmed prices, are to be in force. Unofficial reports indicate that there will be some reductions, although nothing very extensive. There is ground for surmising, however, that a stronger effort will be made later by the Washington authorities for a somewhat lower level of prices. The present is rather an inauspicious time for argument in favor of price reductions, seeing that the mills have passed through a period of several months of exceptionally high costs, due to intermittent operations forced by the traffic situation. They are promised much better operations, but to date the improvement has not been sufficiently great or prolonged to be reflected in cost sheets, and thus it is largely in the form of promise. Two or three months hence the situation will be much clearer in this respect. Either operations will be on a much less abnormal basis or the promise of normal operations will be largely withdrawn.

Whatever the price limits established by the War Industries Board, there is a distinct probability that at times the maximum prices will be shaded as to some commodities, as it is evident that the dislocations produced by excessive war

demands for certain materials on the one hand and greatly reduced peace or commercial requirements for other commodities on the other hand will cause some prices to be less firmly held than others. There will, in essence, be a reversal of the conditions obtaining in the first half of last year, when some commodities, such as plates, were in exceptionally great demand, and plate prices rose above their proper relation with prices for other commodities. Then all prices had a lower limit, based on the market value of semi-finished steel. Now all prices have an upper limit, that set by the Government. The former departures were above the normal average. Any departures in future will be departures downward.

Connellsville coke shipments have been steadily increasing and are now within about 10 per cent of the requirements of the furnaces depending upon Connellsville coke. Supplies of coal to by-product ovens are very nearly equal to requirements, and on the whole the production of pig iron promises to be ample for the requirements of steel mills, restricted as they still are to a considerable extent by inability to make shipments equal to their steel-making and steel-finishing capacity.

Plans are being completed for a thorough control of all the instrumentalities entering into the production and movement of Lake Superior iron ore in the coming season of lake navigation. Last season the effort was to secure maximum vessel movement, and this eventually congested the railroads serving Lake Erie ports. This year everything is to be made subservient to the railroad situation, so as to avoid congestion. The precise requirements of the blast furnaces will be ascertained, and no more ore will be brought down than will suffice them. The movement may be a trifle less than that of last year, as ore has accumulated while the blast furnaces were operating at much less than capacity.

Chemical Market

COAL TAR PRODUCTS.—Trading was of slightly greater volume during the interval, although conditions continue to prevent large volumes of business from passing. The scarcity and high prices of some of the intermediates, coupled with the falling off in export trade, due to the disinclination of the authorities to issue licenses for many of the products, has considerable bearing upon the situation.

Benzol.—The large quantities offered on the market have caused a further reduction in price, and there is not a heavy demand even at present low prices.

Aniline Oil.—The position is slightly easier, due to the liberal offerings through second hands.

Beta Naphthol.—There has been a goodly volume of business passing in the technical grade, but offerings are sufficiently liberal, so that prices are unchanged.

Alpha Naphthylamine.—The demand has been heavier of late than for some time heretofore, and spot material is anything but plentiful.

Phenol.—There is not as great a demand as formerly and, though prices are quotably unchanged, the position is much easier.

Naphthalene.—Prices are well upheld, with offerings light and inquiries fairly plentiful.

Toluol.—Small quantities are offered on the open market, but the Government has commandeered such offerings as it is aware of, and it is unlikely that material will be offered liberally until the Government's needs are covered.

Aniline Salt.—Low offerings are a thing of the past, and producers are keeping the market well in hand.

Dimethylaniline.—Only a few producers are offering. The demand is fair and prices are slightly higher.

Paranitraniline.—Has been in heavy demand of late, and prices are higher, with offerings light.

Benzoate of Soda.—Is slightly easier, due to surplus offerings and light consuming demand.

Ortho Toluidine.—The scarcity of toluol has caused a curtailment in the production, and with an active demand prices have advanced.

Salicylic Acid.—Is offered liberally, and the demand is not heavy, so that it is possible to shade prices.

Para Nitro Phenol.—The production has increased, with

a slight falling off in consuming demand, and it is possible to shade prices.

HEAVY CHEMICALS.—Generally speaking, the markets for these products have been quite dull and lifeless during the past two weeks, and the tendency has been downward as regards values, but at the moment of writing a reaction has set in and in a number of instances an advance has been secured for a number of the important items.

Caustic Soda.—The lowest point that has been reached in months was recorded during the interval when spot 76 per cent solid caustic sold at 3.70. This situation was possibly due to the fact that shipments to this port have been unusually heavy of late and buyers have not appeared as rapidly as arrivals, in consequence of which there was a rather unusual amount of quick liquidation. Shipments from works have been maintained on a much higher parity than spot lots, and producers have never been inclined to meet the prices the second hand interests were establishing. At the moment of writing the market has assumed a very firm tone and there is considerable activity noted, with spot sales as high as 4.50 and producers quoting the same price from the works. There are rumors current of important developments that will tend to not only increase the output of caustic but of establishing a situation that will mean higher prices.

Soda Ash.—In sympathy with caustic the market slumped to a marked degree during the interval, and there were sales of spot rolling ash in bags as low as 2.50. The demand has been unimportant, but on the day this was written an important demand developed and there were sales at 2.75 and 2.80, with some sellers holding to 2.95 ex-store. Barrels have been strong, however, and important business has transpired at prices ranging from 3.15 to 3.25.

Bichromate of Soda.—The market has presented many ear-marks of manipulation, and there have been so many ups and downs during the fortnight that it has not been possible to record them. Sales have occurred at 24c., possibly 25c., but at the moment of writing spot material is available at 21½c., with May shipments at 20½c.

Bichromate of Potash.—Business has been dull, and minor transactions have occurred at prices ranging from 44c. to 45c.

Cyanide of Soda.—There has been no improvement noted and a domestic brand is available at 38c. to 40c., with the English material held at 35c. to 35½c.

Prussiate of Soda.—Considerable activity has been noted of late and sales have occurred at 37c., 37½c. and 38c. Sellers are now refusing to shade 38½c. and the prospects of a still higher market are bright.

Yellow Prussiate of Potash.—In common with most potassium compounds there is a weak market to report for this product. Spot offers have been as low as \$1.20, although for shipment \$1.22 and \$1.25 is asked.

Formaldehyde.—Sales have occurred at 19¼c. but, in view of the fact that the important buying season is developing, sellers are firmer in their ideas and 19½c. is now asked.

Chlorate of Potash.—The market seems to have gone "bust." Spot stocks have accumulated to such an extent that a buyer can name his own price. Probably 1500 casks are available locally. While the nominal price is 40c. to 41c. for domestic business, sales have occurred at 32c., 34c. and 36c. A real buyer could possibly do 30c. for an important amount.

Chlorate of Soda.—In contrast the situation has been firm, and sales have occurred at 24c. and in some instances 25c.

Copper Sulphate.—While the situation is described as somewhat firmer, there are resales of standard brands at 9¼c. to 9½c., and these depress the first-hand market, which is 9½c. Outside brands have sold at 8¼c. and 9c.

Sulphuric Acid.—Offerings have been more liberal, but are not abundant by any means. Acid in sellers' tanks works 66 degree brimstone is held at \$42.00 and \$44.00 drums. Some 60 degree brimstone acid has sold at \$25.00 sellers' tanks works, with offers at \$22.50 buyers' tanks works.

Muriatic Acid.—The situation has been quite firm, and there are important inquiries noted. For the 20 degree

material 2¼c. is quoted, and for the 22 degree 2½c. cannot be shaded, with sales as high as 3c.

Nitric Acid.—Resale lots have depressed the market somewhat, and there have been offers at 8¼c., New York, for the 42 degree. Generally, however, producers will not shade 9c. Carboys continue scarce and restrict the movement.

Oleum.—There have also been more numerous offers of the 20 per cent oleum, and sellers have quoted \$70.00 drums without finding a buyer. Earlier in the interval sales were reported at \$72.50 and \$75.00.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, MARCH 22, 1918

| | | | | |
|---|---------|------------------|---|--------|
| Acetic anhydride..... | lb. | 1.35 | — | 1.50 |
| Acetone, drums..... | lb. | Nominal | | |
| Acid, acetic, 28 per cent..... | lb. | 10 | — | 11 |
| Acetic, 50 per cent..... | lb. | 12 | — | 12½ |
| Acetic, glacial, 99¼ per cent, carboys..... | lb. | 37 | — | 38 |
| Boric, crystals..... | lb. | 13¼ | — | 14¼ |
| Citric, crystals..... | lb. | 74½ | — | 75 |
| Hydrochloric, C. P..... | lb. | 08 | — | 08½ |
| Hydrochloric, 20 deg..... | lb. | 02¼ | — | 02½ |
| Hydrochloric, conc., 22 deg..... | lb. | 02¼ | — | 03 |
| Hydrofluoric, 30 per cent, in barrels..... | lb. | 06 | — | 06¼ |
| Lactic, 44 per cent..... | lb. | 13 | — | 15 |
| Lactic, 22 per cent..... | lb. | 05½ | — | 06½ |
| Nitric, 36 deg..... | lb. | 08¼ | — | 08½ |
| Nitric, 42 deg..... | lb. | 08¼ | — | 09 |
| Oxalic, crystals..... | lb. | 44 | — | 45 |
| Phosphoric, 47-50 per cent paste..... | lb. | 09 | — | 10 |
| Phosphoric, ref. 50 per cent..... | lb. | 26 | — | |
| Picric..... | lb. | Nominal | | |
| Pyrogallol, resublimed..... | lb. | 3.10 | — | 3.15 |
| Sulphuric, 60 deg..... | ton | 25.00 | — | 27.50 |
| Sulphuric, 66 deg..... | ton | 42 00 | — | 44 00 |
| Sulphuric, oleum (Fuming), tank cars..... | ton | 70.00 | — | 75.00 |
| Tannic, U. S. P., bulk..... | lb. | 1.30 | — | 1.35 |
| Tartaric, crystals..... | lb. | 75 | — | 78 |
| Tungstic, per lb. of W..... | lb. | 1.80 | — | 1.90 |
| Alcohol, sugar cane, 188 proof..... | gal. | 4.93 | — | 4.95 |
| Alcohol, wood, 95 per cent..... | gal. | 1.35 | — | 1.38 |
| Alcohol, denatured, 180 proof..... | gal. | 70 | — | 72 |
| Alum, ammonia lump..... | lb. | 04 | — | 04¼ |
| Alum, chrome ammonium..... | lb. | 18 | — | 19 |
| Alum, chrome potassium..... | lb. | 19 | — | 20 |
| Alum, chrome sodium..... | lb. | 12½ | — | 13 |
| Alum, potash lump..... | lb. | 09 | — | 09½ |
| Aluminium sulphate, technical..... | lb. | 01¼ | — | 02¼ |
| Aluminium sulphate, iron free..... | lb. | 02¼ | — | 03¼ |
| Ammonia aqua, 26 deg. carboys..... | lb. | 27 | — | 28 |
| Ammonia, anhydrous..... | lb. | Nominal | | |
| Ammonium carbonate..... | lb. | 11 | — | 12 |
| Ammonium nitrate..... | lb. | (Fixed price) 14 | | |
| Ammonium sulphate domestic..... | lb. | 07¼ | — | 08 |
| Amyl acetate..... | gal. | 5.00 | — | 5.25 |
| Arsenic, white..... | lb. | 16¼ | — | 17¼ |
| Arsenic, red..... | lb. | 65 | — | 70 |
| Barium carbonate, 99 per cent..... | ton | 80.00 | — | 90.00 |
| Barium carbonate, 97-98 per cent..... | ton | 65.00 | — | 67.00 |
| Barium chloride..... | ton | 65.00 | — | 85.00 |
| Barium sulphate (Blanc Fixe, powder)..... | lb. | 03¼ | — | 04 |
| Barium nitrate..... | lb. | 08½ | — | 11 |
| Barium peroxide, basis 70 per cent..... | lb. | 30 | — | 32 |
| Bleaching powder, 35 per cent chlorine..... | lb. | 02¼ | — | 02½ |
| Borax, crystals, sacks..... | lb. | 07¼ | — | 08¼ |
| Bromine, crude..... | ton | Nominal | | |
| Bromine, technical..... | lb. | 75 | — | |
| Calcium, acetate, crude..... | lb. | Nominal | | |
| Calcium, carbide..... | lb. | 14 | — | 14¼ |
| Calcium chloride, 70-75 per cent, fused, lump..... | ton | 23.00 | — | 27.00 |
| Calcium peroxide..... | lb. | 1.60 | — | 1.70 |
| Calcium phosphate..... | lb. | 34 | — | 35 |
| Calcium sulphate 98-99 per cent..... | lb. | 09 | — | 09½ |
| Carbon bisulphide..... | lb. | 08 | — | 10 |
| Carbon tetrachloride, drums..... | lb. | 15¼ | — | 16 |
| Carbonyl chloride (phosgene)..... | lb. | — | — | — |
| Caustic potash, 85-92 per cent..... | lb. | 84 | — | 85 |
| Caustic soda, 76 per cent..... | lb. | 04¼ | — | 05 |
| Chlorine, liquid..... | lb. | 15 | — | 18 |
| Cobalt oxide..... | lb. | 1.60 | — | 1.65 |
| Copperas..... | lb. | 01¼ | — | 01½ |
| Copper carbonate..... | lb. | 30 | — | 40 |
| Copper cyanide..... | lb. | 75 | — | 78 |
| Copper sulphate, 99 per cent, large crystals..... | lb. | 09¼ | — | 09½ |
| Cream of tartar, crystals..... | lb. | 58 | — | 60 |
| Epsom salt, bags, U.S.P..... | lb. | 03¼ | — | 03½ |
| Formaldehyde, 40 per cent..... | lb. | 19¼ | — | 20 |
| Glauber's salt..... | 100 lb. | 1.25 | — | 2.00 |
| Glycerine, bulk, C. P..... | lb. | 68¼ | — | 69 |
| Iodine, resublimed..... | lb. | 4.25 | — | 4.35 |
| Iron oxide..... | lb. | 13 | — | 15 |
| Lead, acetate, white crystals..... | lb. | 17 | — | 18 |
| Lead arsenate (Paste)..... | lb. | 15 | — | 18 |
| Lead nitrate..... | lb. | 15 | — | 16 |
| Litharge, American..... | lb. | 09¼ | — | 11½ |
| Lithium carbonate..... | lb. | 1.50 | — | 2.00 |
| Manganese dioxide, U. S. P..... | lb. | 70 | — | 75 |
| Magnesium carbonate, technical..... | lb. | 10¼ | — | 11 |
| Nickel salt, single..... | lb. | 14 | — | 15 |
| Nickel salt, double..... | lb. | 12 | — | 14 |
| Phosgene, see Carbonyl chloride..... | lb. | — | — | — |
| Phosphorus, red..... | lb. | 1.40 | — | 1.50 |
| Phosphorus, yellow..... | lb. | 1.55 | — | 1.60 |
| Potassium bichromate..... | lb. | 44 | — | 46 |
| Potassium bromide granular..... | lb. | 1.35 | — | 1.50 |
| Potassium carbonate calcined, 85-90 per cent..... | lb. | 95 | — | 1.05 |
| Potassium chlorate, crystals..... | lb. | 36 | — | 40 |
| Potassium cyanide, 98-99 per cent..... | lb. | Nominal | | |
| Potassium iodide..... | lb. | 3.75 | — | 3.80 |
| Potassium muriate 80-85 p. a. basis of 80 p. e..... | ton | 340.00 | — | 350.00 |
| Potassium nitrate..... | lb. | 27 | — | 31 |
| Potassium permanganate (U. S. P.)..... | lb. | 4.00 | — | 4.10 |

| | | | |
|---|---------|---|-------|
| Potassium permanganate, red.....lb. | 2.80 | — | 2.90 |
| Potassium permanganate, yellow.....lb. | 1.20 | — | 1.25 |
| Potassium sulphate, 90-95 p.c. basis 90 p.c.....ton | Nominal | | |
| Rochelle salts.....lb. | .39 | — | .39½ |
| Sal ammoniac, gray gran.....lb. | .16 | — | .17 |
| Sal ammoniac, white gran.....lb. | .15½ | — | .16 |
| Salt cake.....100 lb. | 1.25 | — | 1.30 |
| Salt cake.....ton | 20.00 | — | 25.00 |
| Silver cyanide, based on market price of silver.....oz. | .54½ | — | .55 |
| Silver nitrate.....oz. | .54½ | — | .55 |
| Soda ash, 58 per cent, light, flat.....100 lb. | 2.80 | — | 2.90 |
| Soda ash, 58 per cent, dense, flat.....100 lb. | 3.60 | — | 4.00 |
| Sodium acetate.....lb. | .21½ | — | .22 |
| Sodium bicarbonate, domestic.....lb. | .02½ | — | .03 |
| Sodium bicarbonate, English.....lb. | .02½ | — | .03 |
| Sodium bichromate.....lb. | .21½ | — | .24 |
| Sodium bisulphite, powd.....lb. | .05½ | — | .06 |
| Sodium chlorate.....lb. | .24 | — | .25 |
| Sodium cyanide.....lb. | .38 | — | .40 |
| Sodium fluoride, commercial.....lb. | .17 | — | .18 |
| Sodium hyposulphite.....lb. | .02½ | — | .03 |
| Sodium molybdate, per lb. of Mo.....lb. | 2.50 | — | — |
| Sodium nitrate, 95%.....100 lb. | Nominal | | |
| Sodium nitrite.....lb. | .35 | — | .36 |
| Sodium peroxide.....lb. | .45 | — | .50 |
| Sodium phosphate.....lb. | .03½ | — | .04½ |
| Sodium prussiate, yellow.....lb. | .38½ | — | .40 |
| Sodium silicate, liquid (60 deg.).....lb. | .04½ | — | .05 |
| Sodium sulphide, 30 per cent., crystals.....lb. | .02½ | — | .03 |
| Sodium sulphide, 60 per cent., fused.....lb. | .05 | — | .05½ |
| Sodium sulphite.....lb. | Nominal | | |
| Strontium nitrate.....lb. | .25 | — | .35 |
| Sulphur chloride, drums.....lb. | .06 | — | .06½ |
| Sulphur dioxide, liquid, in cylinders.....lb. | .15 | — | .40 |
| Sulphur, flowers, sublimed.....100 lb. | 4.05 | — | 4.60 |
| Sulphur, roll.....100 lb. | 3.70 | — | 3.85 |
| Sulphur, crude.....ton | Nominal | | |
| Tin bichloride, 50 deg.....lb. | .23½ | — | .24½ |
| Tin oxide.....lb. | .78 | — | .80 |
| Zinc carbonate.....lb. | .25 | — | .30 |
| Zinc chloride.....lb. | .12½ | — | .13 |
| Zinc cyanide.....lb. | Nominal | | |
| Zinc dust, 350 mesh.....lb. | .14 | — | .15 |
| Zinc oxide, American process XX.....lb. | .14 | — | .16 |
| Zinc sulphate.....lb. | .06 | — | .07 |

Coal Tar Products (Crude)

| | | | |
|--|---------|---|-------|
| Benzol, pure, water white.....gal. | .30 | — | .35 |
| Benzol, 90 per cent.....gal. | Nominal | | |
| Toluol, pure, water white.....gal. | .35 | — | .50 |
| Xylol, pure, water white.....gal. | .17 | — | .22 |
| Solvent naphtha, water white.....gal. | .13 | — | .16 |
| Solvent naphtha, crude, heavy.....gal. | .33 | — | .35 |
| Cresote oil, 25 per cent.....gal. | .29 | — | .30 |
| Dip oil, 20 per cent.....gal. | 8.00 | — | 20.00 |
| Pitch, various grades.....ton | 1.05 | — | 1.10 |
| Carbolic acid, crude, 95-97 per cent.....lb. | .60 | — | .65 |
| Carbolic acid, crude, 50 per cent.....lb. | .35 | — | .38 |
| Carbolic acid, crude, 25 per cent.....lb. | .18 | — | .20 |
| Cresol, U. S. P.....lb. | .18 | — | .20 |

Intermediates, Etc.

| | | | |
|--|-------|---|-------|
| Alpha naphthol, crude.....lb. | 1.00 | — | 1.25 |
| Alpha naphthol, distilled.....lb. | 1.60 | — | 2.00 |
| Alpha naphthylamine.....lb. | .60 | — | .62 |
| Aniline oil, drums extra.....lb. | .25 | — | .26 |
| Aniline salts.....lb. | .32 | — | .34 |
| Anthrone, 80 per cent.....lb. | .50 | — | .65 |
| Benzaldehyde (f.f.e.).....lb. | 5.00 | — | 5.50 |
| Benzidine, base.....lb. | 1.75 | — | 1.85 |
| Benzidine, sulphate.....lb. | 1.40 | — | 1.50 |
| Benzic acid U. S. P.....lb. | 4.25 | — | 4.50 |
| Benzene of Soda, U. S. P.....lb. | 4.00 | — | 4.25 |
| Benzyl chloride.....lb. | 2.25 | — | 2.50 |
| Beta naphthol benzene.....lb. | 10.00 | — | 12.00 |
| Beta naphthol, sublimed.....lb. | .85 | — | .90 |
| Beta naphthylamine, sublimed.....lb. | 2.65 | — | 3.00 |
| Dichlor benzol.....lb. | .12 | — | .18 |
| Diethylaniline.....lb. | 4.00 | — | 5.00 |
| Dinitro benzol.....lb. | .35 | — | .40 |
| Dinitrochlorobenzol.....lb. | .40 | — | .42 |
| Dinitronaphthalene.....lb. | .55 | — | .60 |
| Dinitrotoluol.....lb. | .55 | — | .60 |
| Dinitrophenol.....lb. | .46 | — | .50 |
| Dimethylaniline.....lb. | .63 | — | .65 |
| Diphenylamine.....lb. | 1.00 | — | 1.10 |
| H-acid.....lb. | 2.25 | — | 2.50 |
| Metaphenylenediamine.....lb. | 2.00 | — | 2.25 |
| Monochlorobenzol.....lb. | .19 | — | .22 |
| Naphthalene, flake.....lb. | .10½ | — | .11 |
| Naphthalene, balls.....lb. | .12 | — | .14 |
| Naphthionic acid, crude.....lb. | 1.40 | — | 1.50 |
| Naphthylamin-di-sulphonic acid.....lb. | 1.00 | — | 1.10 |
| Nitro naphthalene.....lb. | .45 | — | .50 |
| Nitro toluol.....lb. | .50 | — | .55 |
| Ortho-amidophenol.....lb. | .15 | — | .18 |
| Ortho-dichlor-benzol.....lb. | 1.25 | — | 1.30 |
| Ortho-nitro-toluol.....lb. | .75 | — | 1.00 |
| Para-amidophenol, base.....lb. | 3.50 | — | 4.00 |
| Para-amido-phenol, H. Ch.....lb. | 4.00 | — | 5.00 |
| Para-dichlor-benzol.....lb. | .12 | — | .15 |
| Paranitraniline.....lb. | 1.25 | — | 1.30 |
| Para-nitro-toluol.....lb. | 1.50 | — | 1.60 |
| Paraphenylenediamine (base).....lb. | 3.00 | — | 3.25 |
| Para toluidine.....lb. | 2.25 | — | 2.50 |
| Phthalic acid anhydride.....lb. | 4.50 | — | 5.00 |
| Phenol, U. S. P.....lb. | .53½ | — | .55 |
| Resorcin, technical.....lb. | 6.00 | — | 7.00 |
| Resorcin, pure.....lb. | 9.00 | — | 10.00 |
| Salicylic acid.....lb. | 1.00 | — | 1.10 |
| Solol.....lb. | 1.85 | — | 2.00 |
| Sulphanilic acid, crude.....lb. | .32 | — | .35 |
| Toluidine.....lb. | 2.50 | — | 3.00 |
| Toluidine-mixture.....lb. | .75 | — | .85 |

Petroleum Oils

Crude (at the Wells)

| | | | |
|------------------------|------|---|---|
| Pennsylvania.....bbl. | 4.00 | — | — |
| Corning, Ohio.....bbl. | 2.85 | — | — |

| | | | |
|---------------------------------|------|---|------|
| Somerset, Ky.....bbl. | 2.60 | — | — |
| Wooster, Ohio.....bbl. | 2.38 | — | — |
| Indiana.....bbl. | 2.08 | — | — |
| Illinois.....bbl. | 2.22 | — | — |
| Oklahoma and Kansas.....bbl. | 2.00 | — | — |
| Caddo, La., light.....bbl. | 2.00 | — | — |
| Corcorana, Tex., light.....bbl. | 2.00 | — | — |
| California.....bbl. | .98 | — | 1.32 |
| Gulf Coast.....bbl. | 1.35 | — | — |

Fuel Oil

| | | | |
|------------------------|------|---|------|
| New York.....gal. | .11 | — | — |
| Pittsburgh.....gal. | .07½ | — | .10 |
| Oklahoma-Kans.....bbl. | 1.50 | — | 2.35 |
| Texas.....bbl. | 1.50 | — | 1.90 |
| Los Angeles.....bbl. | 1.52 | — | — |
| San Francisco.....bbl. | 1.45 | — | — |

Gasoline (Wholesale)

| | | | |
|------------------------|-----|---|---|
| New York.....gal. | .24 | — | — |
| Boston.....gal. | .25 | — | — |
| Pittsburgh.....gal. | .26 | — | — |
| Chicago.....gal. | .21 | — | — |
| Oklahoma.....gal. | .25 | — | — |
| San Francisco.....gal. | .20 | — | — |

Lubricants

| | | | |
|--|-----|---|-----|
| Black, reduced, 29 gravity, 25-30 cold test.....gal. | .21 | — | .22 |
| Cylinder, light.....gal. | .36 | — | .38 |
| Cylinder, dark.....gal. | .35 | — | .36 |
| Paraffine, high viscosity.....gal. | .40 | — | .41 |
| Paraffine, 903 sp. gr.....gal. | .33 | — | .34 |
| Paraffine, .865 sp. gr.....gal. | .22 | — | .23 |

Flotation Oils

(Prices at New York unless otherwise stated)

| | | | |
|--|-----|---|-----|
| Pine oil, crude, f.o.b. Florida.....gal. | .44 | — | — |
| Pine oil, steam distilled, sp. gr. 0.925-0.940.....gal. | .53 | — | — |
| Pine oil, destructively distilled.....gal. | .49 | — | .53 |
| Pine-tar oil, sp. gr. 1.025-1.035.....gal. | .35 | — | — |
| Pine-tar oil, double refined, sp. gr. 0.965-0.990.....gal. | .40 | — | — |
| Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works.....gal. | .37 | — | — |
| Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works.....gal. | .26 | — | — |
| Pine tar, thin, sp. gr. 1.060-1.080.....gal. | .30 | — | — |
| Turpentine, crude, sp. gr. 0.980-1.000.....gal. | .40 | — | — |
| Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990.....gal. | .19 | — | — |
| Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08.....gal. | .19 | — | — |
| Wood creosote, ref. f.o.b. Florida.....gal. | .31 | — | — |

Vegetable and Other Oils

| | | | |
|----------------------------------|------|---|------|
| China wood oil.....lb. | .21 | — | .22 |
| Cottonseed oil, crude.....lb. | .17½ | — | .18 |
| Linseed oil, raw, cars.....gal. | 1.55 | — | 1.57 |
| Peanut oil, crude.....gal. | 1.37 | — | — |
| Rosin oil, first run.....gal. | .35 | — | — |
| Rosin oil, fourth run.....gal. | .66 | — | — |
| Soya bean oil, Manchuria.....lb. | .19 | — | .19½ |
| Turpentine, spirits.....gal. | .44½ | — | — |

Miscellaneous Materials

| | | | |
|---|-------|---|-------|
| Barytes, floated, white, foreign.....ton | 40.00 | — | 50.00 |
| Barytes, floated, white, domestic.....ton | 30.00 | — | 36.00 |
| Beeswax, white, pure.....lb. | .56 | — | .64 |
| Casein.....lb. | .22 | — | .30 |
| Chalk, light, precipitated, English.....lb. | — | — | — |
| China clay, imported, lump.....ton | 17.50 | — | 36.00 |
| China clay, domestic, lump.....ton | 12.50 | — | 20.00 |
| Feldspar.....ton | 8.00 | — | 12.00 |
| Fuller's earth, powdered.....100 lb. | 1.00 | — | 1.50 |
| Osokerite, crude, brown.....lb. | .65 | — | .75 |
| Osokerite, American, refined, white.....lb. | .75 | — | 1.00 |
| Red lead, dry, carloads.....lb. | .30 | — | .11½ |
| Rosin, 250 lb.....bbl. | 6.65 | — | — |
| Soapstone.....ton | 10.00 | — | 12.50 |
| Talc, American, white.....ton | 15.00 | — | 22.00 |
| White lead, dry.....lb. | .09 | — | .10 |

Refractories, Etc.

(F.O.B. Works)

| | | | |
|---|---------|---|--------|
| Chrome brick.....net ton | Nominal | | |
| Chrome cement, Grecian.....net ton | Nominal | | |
| Clay brick, lat quality fireclay.....per 1000 | 50.00 | — | 55.00 |
| Clay brick, second quality.....per 1000 | 35.00 | — | 40.00 |
| Magnesite, raw.....ton | 30.00 | — | 35.00 |
| Magnesite, calcined.....ton | 32.00 | — | 35.00 |
| Magnesite, Grecian, dead burned.....net ton | 85.00 | — | 90.00 |
| Magnesia brick, Grecian, 9x4½x2½.....net ton | 135.00 | — | 140.00 |
| Silica brick.....per 1000 | 50.00 | — | 60.00 |

Ferroalloys

| | | | |
|--|--------|---|--------|
| Ferrocobaltitium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y.....ton | 160.00 | — | — |
| Ferrocobaltium.....lb. | 18.00 | — | — |
| Ferrocobaltium, per lb. of Cr.....lb. | .60 | — | — |
| Ferromanganese, domestic.....ton | 250.00 | — | — |
| Ferromanganese, English.....ton | 325.00 | — | — |
| Ferromolybdenum, per lb. of Mo.....lb. | 5.00 | — | — |
| Ferrosilicon, 75 per cent, f.o.b. N. Y.....ton | — | — | — |
| Ferrosilicon, 50 per cent, carloads, del., Pittsburgh.....ton | 170.00 | — | 195.00 |
| Ferrosilicon, 50 per cent, contract.....ton | 100.00 | — | 175.00 |
| Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh.....lb. | 2.30 | — | 2.35 |
| Ferrotungsten, f.o.b. works, per lb. of U.....lb. | 7.00 | — | — |
| Ferrovandium, f.o.b. works.....lb. | 4.00 | — | 5.00 |

Ores and Semi-finished Products

| | | | |
|--|-------|---|--------|
| Antimony ore, per unit.....lb. | 1.60 | — | 1.75 |
| Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit.....ton | 1.50 | — | 1.60 |
| Chrome ore, 43 per cent and over, New York, per unit.....ton | 1.50 | — | — |
| Manganese ore, 48 per cent and over, per unit.....ton | 1.20 | — | — |
| Manganese ore, chemical.....ton | 80.00 | — | 100.00 |
| Molybdenite, per lb. of MoS ₂.....lb. | 1.80 | — | — |
| Tungsten, Scheelite, per unit of WO ₃.....ton | 20.00 | — | 24.00 |
| Tungsten, Wolframite, per unit of WO ₃.....ton | 20.00 | — | 24.00 |
| Uranium oxide, 96%.....lb. | 3.25 | — | 3.60 |
| Vanadium pentoxide, 99%.....lb. | 10.50 | — | — |
| Pyrites, foreign.....unit | .17 | — | .17½ |
| Pyrites, domestic.....unit | .28 | — | .30 |

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

THE ALPHANO HUMUS COMPANY, Boonton, N. J. Capital, \$4,000,000. To engage in the manufacture of fertilizers. Incorporators: John N. Hoff, Boonton; Richard Sellers, Bellevue, Del., and James E. Mantee, Portland, Me.

AMERICAN ALLOY AND CHEMICAL CORPORATION. Capital stock, \$1,000,000. Directors: J. L. Boyle, G. A. Green, G. H. Beesemeyer, F. L. Riley, B. J. Quinn, A. J. Morse, J. I. Stevens.

THE AMERICAN INDUSTRIAL ENGINEERING COMPANY is a new enterprise with offices in the Monadnock Block, 53 West Jackson Boulevard, Chicago, which is headed by L. W. Lauren, president, and L. H. Bergman, vice-president.

Mr. Lauren was formerly vice-president of the Reynolds Wire Co., of Dixon, Ill., and Mr. Bergman was until a short time ago fuel engineer for the Midvale Steel Co. of Philadelphia, Pa.

The company, which is incorporated, will make a specialty in wire mill equipment, pulverized fuel installation, furnace work and fuel economy.

THE AMERICAN RECLAIMING & REFINING COMPANY, Bayonne, N. J. Capital, \$250,000. To engage in the refining and reclaiming of metals. Incorporators: Bernard Rubine, Charles and Harry B. Dembe, 19 West Twenty-seventh Street, Bayonne.

THE ANDERSON COUNTY MICA COMPANY, Anderson, S. C. Capital, \$100,000. To develop mica properties in Anderson County. Incorporators: J. J. Fretwell, N. J. Fretwell, Jr., and Raymond Fretwell, all of Anderson.

THE ARIZONA BAGDAD COPPER COMPANY, Dover, Del. Capital, \$1,750,000. To mine for copper. Incorporators: Edward C. Christensen, E. B. Brownson, and Frederick C. Hary, all of New York.

THE R. M. BAILEY COMPANY, Dover, Del. Capital, \$50,000. To manufacture iron and steel products. Incorporators: Charles B. Bishop, S. H. Baynard, Jr., and A. M. Fox, Wilmington.

THE BLUE RIDGE PAINT & COLOR COMPANY, Allentown, Pa. Capital, \$10,000. To manufacture paints, varnishes, etc. A. W. Thompson is the principal incorporator.

THE BUCYRUS TIRE & RUBBER COMPANY, Buffalo, N. Y. Capital, \$200,000. To manufacture automobile tires, tubes, etc. Incorporators: C. O. Henderson, Philip H. Heater, Bucyrus, Ohio, and George C. Riley, Buffalo.

THE DAY CHEMICAL COMPANY, Chicago, Ill. Nominal capital, \$5,000. To manufacture chemicals and allied products. Incorporators: James B. Day, Robert A. Levenner, R. H. Clinton, and Hilgard B. Young, Chicago.

THE DINGLE-CLARK COMPANY has been organized with offices at 536 Engineers Building, Cleveland, Ohio. This corporation will handle a complete line of motors, transformers, controllers, turbo-gears, and are in a position to install electrical equipment for any size plant with complete technical and financial responsibility assured. Mr. Howard Dingle and Mr. W. W. Clark were up to February 1, respectively, district manager and assistant manager of the Crocker-Wheeler Company in Cleveland.

THE EDMANSON & BATES COMPANY, Buffalo, N. Y. Capital, \$150,000. To manufacture chemicals, etc. Incorporators: B. W. Stuart, E. M. Fitemorris, and J. L. Kinney, Buffalo.

THE GREAT WESTERN LEAD & ZINC COMPANY, Miami, Okla. Capital, \$100,000. To mine for lead and zinc. Incorporators: M. B. Rook, Miami; Edward Kesler, Carter, and J. G. Wherry, Commerce, Okla.

THE HART GLASS MANUFACTURING COMPANY, Dunkirk, Ind. Capital, \$200,000. To manufacture glass and glassware of various kinds. Incorporators: Francis H. May, Thomas F. and T. Francis Hart, Dunkirk.

THE IDAHO COPPER COMPANY, Chicago, Ill. Capital, \$250,000. To engage in a general copper mining business. Incorporators: William C. William O. Rouss and James A. Crotty, Chicago.

THE INDEPENDENT CHEMICAL COMPANY, Dover, Del. Capital, \$4,500,000. To manufacture chemicals and allied products. Incorporators: W. B. Walsh, Brooklyn, J. A. Lyon, New York, and V. Harris, Pelham Manor, N. Y.

THE JEFFERSON GRAPHITE COMPANY, Birmingham, Ala. Capital, \$20,000. To engage in the production of graphite. Incorporators: George R. Sincix, L. B. Gunville, and M. Hughes, Birmingham.

THE JOHNSON CHEMICAL COMPANY, Raleigh, N. C. Capital, \$200,000. To manufacture chemicals and kindred specialties. Incorporators: James I. Johnson, James I. Johnson, Jr., and J. W. Cross, Raleigh.

THE KENSINGTON BRASS FOUNDRY & MANUFACTURING COMPANY, Philadelphia, Pa. Capital, \$50,000. To manufacture brass, iron, steel, etc. Incorporators: Thomas W. Moore, L. V. Gillian and J. D. Levy, all of Philadelphia.

THE KRAYER CHEMICAL COMPANY, Elizabeth, N. J. Capital, \$50,000. To engage in the manufacture of chemicals. Incorporators: Dr. Stephen S. Krayer, A. Krayer, H. Jacobs and Clarence S. Myer, Elizabeth.

THE LIBERTY LEATHER COMPANY, Dover, Del. Capital, \$100,000. To manufacture leather and leather products. Incorporators: M. L. Harty, F. D. Buck and K. E. Longfield, Wilmington.

THE L. N. N. FOUNDRY COMPANY, Cleveland, O. Capital, \$20,000. To operate a general foundry business. Incorporators: H. H. Neuman and C. E. Lyall, Cleveland.

LOWE BROTHERS COMPANY, Springfield, Ill. Capital, \$47,000. To manufacture paints, varnishes, etc. Houston Lowe is president.

THE LUCKEY LEAD & ZINC MINING COMPANY, Tishomingo, Okla. Capital, \$25,000. To mine for lead and zinc, etc. Incorporators: George W. Dudley, C. W. Burton, Tishomingo and J. J. McKanna, Joplin, Mo.

THE LUTZ COMPANY, INC., of NEW JERSEY, Camden, N. J. Capital, \$125,000. To operate a general foundry and machine shop. Incorporators: William H. Lutz, Samuel Mason and Joseph S. Pedrick, Camden.

Construction and Operation

Alabama

EUFAULA.—Fire, on March 10, destroyed the entire plant of the Eufaula Cotton Oil Company, with total loss estimated at \$65,000. The entire equipment of crushing and other machinery was also totally destroyed. The company has plans under consideration for the immediate reconstruction of the plant.

FLORENCE.—Operations are being rushed in connection with the construction of the new Government nitrate plant at Muscle Shoals, and it is expected that the first unit of the works will be completed and ready for operation by June 1.

Arizona

HUMBOLDT.—The Consolidated Arizona Smelting Company has commenced the construction of four Wedge mechanical roasting furnaces, each 22½ feet in diameter, having seven hearths for roasting and one for drying, the furnaces to be equipped with individual Cottrell dust-precipitators. When the new furnaces are completed, the plant will have a capacity of 600 tons of wet charge per twenty-four hours, or 150 tons per furnace per twenty-four hours, producing a calcine containing 8 per cent sulphur. The company is planning ultimately to double the capacity of the entire plant.

Arkansas

COTTER.—The Dixie Girl Mining Company is planning for the immediate installation of new equipment at its lead and zinc producing plant, including tables, compressors and air drills, to increase the

present capacity of the plant. A. C. Barnhart is superintendent.

SPYKER.—The Southern Carbon Company is considering the immediate installation of new gasoline-making machinery in its plants at Spyker and Fairbanks.

California

JACKSON.—The Fortuna Mining Company is planning for the construction of a new concentration mill at its plant. The company has commenced the erection of a new electric power line at its works near Bellevue.

CORCORAN.—L. B. Dapron is considering plans for the construction of a new four-stand cotton gin at Corcoran and a smaller plant at Fresno.

BAY POINT.—The Pacific Electro-Metals Company is experimenting with electrodes, and when satisfactory results are accomplished the company will take steps toward building the second unit of this establishment.

HERCULES.—One of the largest plants in the United States for the manufacture of trinitrotoluene for the army and navy is to be erected at once as an addition to the plant of the Hercules Powder Company at Hercules, Cal., according to advices received from Washington by the San Francisco Chamber of Commerce. The construction work on the plant is to be started at once and rushed with all possible speed. According to Warren H. McBryde, assistant superintendent for the Hercules Company, approximately 2000 men and women will be employed in the new plant.

CRUCERO.—The Tecopa Mines Company is planning for the construction of a new smelter at its local plant. Plans are also under consideration for a smelter at Tecopa. L. D. Godshall, Los Angeles, is in charge.

KLAMATH FALLS.—The Klamath Iron & Steel Company, recently incorporated with a capital of \$20,000, has recently acquired a tract of three lots on Elm and Spring Streets as a site for the construction of a new foundry and machine shops. Contracts for the new works have been awarded. R. D. Cartensen is president; J. P. Fitzpatrick is secretary-treasurer, and D. M. Hall is general manager.

LOS ANGELES.—The Baker Iron Works, North Broadway, is planning for the immediate construction of a new two-story addition to its plant to cost about \$5,500. Plans for the structure have been filed.

SAN FRANCISCO.—The Independent Steel Mills of Pittsburgh, Pa., which control the Liberty Steel Products Company, the Pittsburgh Steel & Pressed Car Works, and other corporations, are reported to be considering a number of sites on San Francisco Bay for the erection of a large new steel plant. P. G. Buerk is representing the companies.

Colorado

LEADVILLE.—The Star Consolidated Mining Company is making rapid progress in the construction of its new 300-ton mill, and the first 100-ton unit of the plant has been completed. The new plant will dress ore from the large bodies of low-grade iron-manganese deposits on the company's properties.

NEDERLAND.—Organization plans have been completed by the Malmo Mining & Milling Company, and it is planned to install the necessary machinery at the company's holdings. C. E. Bradenburg heads the company.

CLIMAX.—The new mill being erected at Burfehr's spur by the Molybdenum Products Company is being rushed to completion, and it is expected that the plant will be ready for operation at an early date. A. B. Scott is manager.

DENVER.—The Queen City Foundry Company, Denver, Col., has placed an order for a one-ton Booth-Hall electric steel furnace to replace the converter equipment now being used by that company. The furnace has a holding capacity of three-quarters to one ton, and is rated at 300 kva. Power will be delivered to the furnace by the Denver Gas and Electric Company.

PUEBLO.—The Norcross Chemical Company of Denver is constructing a sulphuric and nitric acid plant here. The Kalberry Corporation of New York are the consulting and designing engineers.

Delaware

WILMINGTON.—The E. I. duPont de Nemours Company is planning for the construction of a new shell-loading plant on property recently acquired at Dundalk, Md.

Georgia

ATLANTA.—The Hec Manufacturing Company, 82 Marietta Street, is planning to increase the capacity of its plant by the installation of new equipment, to be devoted to the production of steel, brass and copper specialties.

Illinois

CHICAGO.—The U. S. Reduction Company recently purchased a tract of land of about 600 acres in Colorado. The present plans are to erect a large aluminium factory on this site.

CHICAGO.—The J. Greenbaum Tanning Company has recently purchased property at the northeast corner of Elston and Warsaw Streets, about 100 x 120 feet, for a consideration of \$12,000. The property adjoins the company's tannery, and it is planned to construct a large new addition, for increased capacity, at a cost of about \$100,000.

EAST CHICAGO.—The Sinclair Oil Refining Company has inaugurated operations in its new local refinery, oil having reached that point from the company's Oklahoma and Kansas properties through the new pipe line recently completed.

Indiana

TERRE HAUTE.—Colonel Gooderham of Toronto, and Captain Burton, an English officer, composing a British mission on manufacture of explosives, were here recently letting contracts and arranging for the opening of the old Commercial distillery as a factory for making acetone, the chemical base of cordite, an explosive, and "dope" for airplane wings. This will be manufactured from corn. Priority shipment of special machinery has been assured, and it is believed manufacture will be started within a few weeks. The final transfer of the plant from the John Edward Beggs interests to the British government were completed in New York.

WABASH.—Oscar Frosell, a Swedish-German chemist, who has been doing governmental experimental work here for some time, announced today that he has succeeded in making the first American magnelith, a material used for the deck floors of battleships. The material has been given rigid tests and cannot be checked or cracked by bullets. Magnesite, a magnesium cement, the base from which magnelith is manufactured, was obtained from the Pacific coast.

Iowa

CEDAR RAPIDS.—The La Plant-Choate-Williams Company is planning for the establishment of a new department at its plant and will install a complete new foundry building for the production of steel castings, etc. A five-ton open hearth furnace will be installed for initial operations. J. S. Williams will be in charge of the casting production department.

OTTUMWA.—The plant of the Morey Clay Products Company was recently damaged by fire to the extent of \$30,000.

Kansas

BAXTER.—The Aksarben Mining Company is planning for the construction of a new concentration mill on the Cooper properties, recently leased by the company. John Vochees is president.

BAXTER SPRINGS.—The N. S. Sherman Iron Works Corporation is planning for the immediate construction of a new foundry and machine shop, about 40 x 80 feet, and 150 x 150 feet, respectively, both one-story structures.

TREECE.—The Commonwealth Lead & Zinc Company is considering plans for the erection of a large new mill at its properties. Extensive development work has been in progress for some time, and a good deposit at 260 feet depth has been opened.

Kentucky

LEXINGTON.—The Southwestern Petroleum Company has recently secured oil lands in Clay, Chiles, and Miller, Lee County, located on Cave Fork, Bald Rock, and Sinking Creek, for a consideration said to be about \$40,000, and is planning for extensive development work.

WHITESBURG.—The Indian Refining Company has completed plans for the laying of a new pipeline, four-inch, from its new oil territory in Powell County to Ravanna, on the Kentucky River, a distance of about thirty miles.

Louisiana

DONALDSONVILLE.—The Norman Planting Company, which recently acquired the Belle Alliance and Evan Hall sugar plantations, is said to be planning for the construction of new additions to the refinery to provide for increased capacity. A. W. Norman heads the company.

Maryland

BALTIMORE.—Plans have been prepared by the Western Maryland Railroad Company, Continental Building, for the erection of a new one-story shop addition at its wheel works at Hagerstown. The structure will be about 30 x 35 feet, and is estimated to cost \$10,000.

PERRYVILLE.—The Atlas Powder Company has begun the construction of a \$6,000,000 plant for the manufacture of nitrate of ammonia from sodium nitrate and ammonium sulphate, according to announcement. The company is acting for the government, and at the end of the war the government will take over the plant. The company has 2000 men at work constructing the foundation for the plant on the site at Perry Point farm, at the junction of the Susquehanna River and Chesapeake Bay, near Perryville, Md. The plans call for the plant's completion by July 1, and afterward 1000 hands will be employed in manufacturing the nitrate for use in making explosives.

Massachusetts

SPRINGFIELD.—The Smith Foundry Company is planning for the removal of its plant to Greenfield, and will increase the capacity of the plant by the installation of new equipment.

WEST SPRINGFIELD.—The Gilbert & Barker Manufacturing Company is making rapid progress in the construction of new additions to its plant to cost about \$80,000. The capacity of the power house is also being increased.

Michigan

DETROIT.—Fire recently destroyed the four-story plant of the Monarch Steel Castings Company, which was engaged upon war contracts, with total loss estimated at \$350,000. A number of valuable patterns were also destroyed.

MIDLAND.—The government has taken over the Dow Chemical works at Mt. Pleasant and Midland and will advance \$2,000,000 for enlargement and new equipment in order to adequately supply the chemicals needed in the manufacture of munitions.

Mr. Dow will continue in the management as now, but otherwise it will be conducted as a government industry. A large number of new wells are to be put down, as fast as possible, between Mt. Pleasant and Midland, a pipeline will be laid between the two plants and a big power plant built somewhere between the two cities, which will supply light and power the whole length of the line.

GRAND RAPIDS.—The Grand Rapids Varnish Company, which recently acquired property adjoining its plant on Godfrey Avenue, has had plans prepared for the construction of a new addition, about 40 x 60 feet, which will be used as an extension to its enamel manufacturing department.

HOUGHTON.—Plans are under consideration by the Seneca Mining Company, operating the Seneca mine, for the immediate reconstruction of its machine and forge shops, recently destroyed by fire.

MARQUETTE.—The Cleveland Cliff Iron Company, Cleveland, Ohio, has commenced the reconstruction of the local alcohol refinery of the Pioneer Iron Works, which it controls. This plant was recently destroyed by fire, and the new works are estimated to cost about \$250,000.

Minnesota

DULUTH.—The Zenith Furnace Company has taken out a building permit for the construction of a new concrete and steel gas holder to have a capacity of 1,000,000 cubic feet. The estimated cost of the work is \$135,000.

Missouri

SENECA.—The Wyandotte Zinc Company is considering plans for the immediate construction of a new concentrating plant at its properties.

ST. LOUIS.—The Monsanto Chemical Works, 1800 South Second Street, has recently acquired the plant of the Commercial Acid Company, East St. Louis, Ill., for a

consideration said to be in the neighborhood of \$2,000,000. The company recently increased its capitalization to \$5,000,000 for this purpose. The plant of the Commercial company includes a site of 114 acres, with twenty-five factory buildings, machinery equipment, etc., and it is planned to continue the manufacture of sulphuric acid, nitrate acid, carbolic acid, etc.

ST. LOUIS.—The Engel Paper Box Specialty Company, 1906 Pine Street, is planning for the installation of new machinery for the manufacture of paper cans and tubes in connection with its present box-making plant. W. W. Stroop is secretary.

Montana

BANNACK.—C. W. Stalling has recently leased the Hendricks gold mine, and is considering the construction of a new 5-stamp mill.

Nebraska

OMAHA.—The Henry R. Gering Company has acquired property at 1114-16 Farnam Street, and will make alterations and improvements in the structures for the establishment of a new chemical manufacturing plant.

Nevada

BULLION.—William Patterson and J. D. McFarlane are planning for the construction of a new local smelter for the handling of ore produced in Bullion and vicinity. F. G. Buick is engineer.

JARBRIDGE.—The Elkoro Mines Company has inaugurated operations at its new 150-ton cyanide mill. The new plant is operated entirely by electricity, which is generated at Thousand Springs.

New Jersey

EAST NEWARK.—The Ohio Cities Gas Company has acquired the plant of the Pure Oil Company, about 105 x 330 feet, on Passaic Avenue, and about 5 acres of land on Passaic Avenue near the Lincoln Highway, Kearny Meadows. It is said the property will be used for extensions.

NEWARK.—The Maas & Waldstein Company, Avenue R, manufacturer of chemicals, has recently taken out a building permit for alterations at its plant. The company is also planning for the erection of a new addition to cost \$12,000.

BAYONNE.—Fire, on March 18, destroyed one of the new high pressure tubular stills at the plant of the Tide Water Oil Company, with loss estimated at \$50,000.

CAMDEN.—The R. M. Hollingshead Company, manufacturer of oils, greases, etc., has taken out a building permit for the construction of a new brick addition to be located at Ninth and Market Streets.

BELLEVILLE.—The Lloyd Chemical Works, with plant in Holmes Street, is planning to purchase the site formerly owned by the Kent Motors Corporation, covering about 16 acres, from Washington Avenue to the Passaic River. It is understood that a large new chemical manufacturing plant will be erected by the company, comprising several three-story brick structures, to facilitate the handling of a \$40,000,000 Government contract which the company holds. An expenditure of approximately \$2,000,000 will be involved in the project.

WHARTON.—The Wharton Steel Company's iron ore mines, which consist of three mines—Scrub Oak, Oreland and Andover, have just been connected up. To connect these mines it was necessary to build six miles of 33,000 volt lines and one mile of 11,000 volt lines.

The Wharton Steel Company expects these mines to turn out about 2,000 tons of ore per day, which will take care of their furnaces at Wharton. The Steel Company owns the ore mines and also the railroad running from the mines to the furnaces. The mines run around 45 per cent before being concentrated and after being concentrated run about 65 per cent. At the present time The Wharton Steel Company is selling pig iron to the Bethlehem Steel Company and the Italian Government.

New York

OLEAN.—The chemical plants in this vicinity conducted for the distillation of hardwood have had their products, acetate of lime and acetone, commandeered by the war department. The following plants are in this section: Vandalia Chemical Company, Straight Creek Chemical Company, Susquehanna Chemical Company, Lacka-

wanna Chemical Company, Keystone Wood Products Company, Smethport Wood Products Company, Corryville Chemical Company, Newton Chemical Company, Heinemann Chemical Company, Norweld Chemical Company, Smith Chemical Company, Minard Run Chemical Company, Lewis Run Chemical Company, and Custer City Chemical Company. Nearly all of these concerns have their main offices in Olean.

The 14 concerns, named above, employ 1000 at their plants and, in addition, at this season of the year keep 4000 men as teamsters and wood cutters, busy in the woods supplying chemical wood. The acetone produced by these concerns is largely used in the manufacture of high explosives, being indispensable for certain processes.

ALBANY.—A chemical plant costing \$1,000,000 is to be constructed by the Federal Government at Mechanicsville to utilize the by-products of paper manufacturing plants of the West Virginia Pulp and Paper Company. The Government is to manufacture acetone, which is to be used to mix with varnish for coating airplane wings.

NEW YORK.—The Central Smelting & Refining Company, 220 Rider Avenue, is said to be planning for extension to its plant on property recently acquired on Third Street, Long Island City, about 75x180 feet.

YONKERS.—Fries & Fries, Cincinnati, Ohio, manufacturers of chemicals, etc., have acquired property comprising about one and one-half acres from Woodworth Avenue to the New York Central Railroad, to be used for the manufacture of waterproof coatings, syrups, etc.

LONG ISLAND CITY.—Plans have been filed by the Pittsburgh Plate Glass Company, for the construction of its proposed new two-story plant, about 265 x 270 feet, on Hunters Point Avenue. The structure will contain about 102,000 square feet, and is estimated to cost \$200,000.

SYRACUSE.—The Savage Arms Corporation is considering the erection of a large addition to its plant to increase the present capacity by approximately 5000 machine guns per month. It is said that the company has Government contracts on hand at the present time which will occupy practically all of 1918.

Ohio

MOUNT GILEAD.—The extensive new buildings of The Hydraulic Press Mfg. Company at Mount Gilead, Ohio, are now occupied and the plant is again in operation to its full capacity. The new equipment represents the most advanced types of metal working machinery available and is specially adapted for the building of hydraulic presses, pumps and valves.

CINCINNATI.—The Troy Metal Products Company, recently incorporated with a capital of \$300,000, is negotiating with the Huenefeld Company, Spring Grove Avenue and Straight Street, for the occupation of the latter's plant to engage in the manufacture of munitions.

CARTHAGE.—The Pollak Steel Company is planning for the construction of a large new plant, to be devoted to the manufacture of equipment for torpedo destroyers. The new works are estimated to cost about \$500,000, and will give employment to about 1000 hands.

CLEVELAND.—The Aetna Steel Castings Company has awarded a contract for the construction of a new foundry building, about 100 x 165 feet, at 2284 Scranton Road, Southwest, to cost \$15,000.

COLUMBUS.—The Atlas Brass Foundry Company, 980 South Park Street, manufacturer of brass, bronze, and aluminum castings, and screw machine products, has taken bids for the construction of a new three-story brick addition, about 40 x 65 feet.

TOLEDO.—The Toledo Electric Steel Company, manufacturer of high speed and special alloy steels, is planning for the erection of a new steel mill building to increase the capacity of the plant. A 12-inch three-high tool steel bar rolling mill with drive, three water-tube boilers, 3-ton electric furnace, and 5, 3 and 1-ton hammers will be installed.

Oklahoma

PICHER.—The Southwestern Missouri Mining Company is considering plans for the construction of a new 500-ton concentrating plant on its 40-acre lease of zinc properties between Picher and Treece, Kan.

QUAPAW.—The Kentex Mining Company is planning for the construction of a new mining and milling plant at its properties, to cost about \$100,000. S. C. Kennedy is manager.

QUAPAW.—The Bethlehem Zinc Company is considering the erection of a new mill at its properties. T. Wade is president.

QUAPAW.—The Lucky Joe Mining Company has commenced the construction of a new 250-ton concentration plant at its lead and zinc properties. J. P. Matthews is manager.

Oregon

GOLD HILL.—O. C. Runnals, Seattle, Wash., and associates, have acquired the Utah Mining Properties, located about twelve miles from Gold Hill, and are planning the erection of an electric transmission line, about five miles long, to connect with the lines of the California-Oregon Power Company. It is proposed to equip the mines with electrically operated machinery.

Pennsylvania

PHILADELPHIA.—The Gorgas-Pierle Company, 126 East Allen Street, manufacturer of seed oils, etc., has awarded a contract to the Turner Concrete Steel Company, 1713 Sansom Street, for the construction of a new two-story brick and concrete addition, about 55 x 75 feet, to cost \$15,000.

PITTSBURGH.—The plant of the Walker-Stratman Company, Herrs Island, near Pittsburgh, was destroyed by fire on March 8. The company was engaged in the manufacture of glycerin for Government use in high explosives.

RITERSVILLE.—The Noeque Chemical Company, recently incorporated in Philadelphia with a capital of \$450,000, is considering the construction of a large local manufacturing plant.

TYRONE.—The West Virginia Pulp & Paper Company has commenced the construction of its proposed new local plant, comprising eight manufacturing buildings. The new works are estimated to cost \$500,000. The George A. Fuller Company, 949 Broadway, New York, is the contractor.

NEW CASTLE.—A nitric acid plant costing \$1,000,000 will be erected as an addition to the Covert's station powder plant of the Grasselli Chemical Co. Construction work has already started.

SCRANTON.—The American Color Company, which is constructing a \$50,000 plant at Scranton, Pa., will begin the manufacture of direct cotton colors about April 1. Benj. C. Warnick is president, Clifford Stone Cooley, vice-president and general manager, and E. B. Jermyn, treasurer.

Tennessee

COLLINWOOD.—The Government is building a large wood chemical plant in Collinwood to procure acetate of lime and wood alcohol for munitions. Collinwood is located in the center of Wayne County, and the center of a wilderness of timber. Contract for the plant was made with the Tennessee Valley Iron and Railroad Company, a Pittsburgh concern, which owns 90,000 acres of land in this county, and which will operate the plant for the Government. The plant is to cost \$2,000,000 and be completed in eight months. Thompson-Starrett Company of New York will erect the plant. This will be the largest plant of its kind in the world and will use 200 cords of wood a day.

The Government will require all the products except the charcoal which will be used in the manufacture of pig iron.

DUCKTOWN.—The Tennessee Copper Company, 11 Broadway, New York, is planning to increase the capacity of its local sulphuric acid plant to 3,000,000 tons annually.

MEMPHIS.—The Webster-Warnock Chemical Company is having plans prepared for the reconstruction of its chemical manufacturing plant recently destroyed by fire with loss estimated at \$25,000.

HADLEY'S BEND.—The United States Government War Department is planning to have a daily capacity of 1,000,000 pounds of smokeless powder and 1,000,000 pounds of gun cotton at its new local explosives plant, which will represent an expenditure of \$100,000,000 instead of \$60,000,000 as previously announced. The duPont Co. has charge of the construction work.

KINGSFORD.—Information has been received of the location of an alcohol plant at Kingsford, Tenn. The Government is behind the enterprise which, when completed, will cost \$1,250,000, and will give employment to a thousand men. It is understood that the product of the plant will be used for polishing gunstocks for which maple and beech lumber is used. The by-product

will be converted into charcoal which has a ready market at the time. Already 35 acres of land have been secured and work will go forward at once.

Texas

BROWNWOOD.—Rapid progress is being made by the Gotebo Oil, Gas & Refinery Company in the construction of its new local refinery, and it is expected that the plant will be in operation at an early date.

BROWNWOOD.—The Brown-Ard Refining Company, Ardmore, is considering the construction of a large new oil refinery on a tract of land comprising 26 acres on the Hall property west of Brownwood. The new plant will have an initial capacity of about 1,000 barrels daily.

ROCKDALE.—Henry M. Butler, Humber, and associates, have completed arrangements for the development of a large bed of lignite recently purchased, near Rockdale. It is planned to mine the fuel by means of steam shovels.

Utah

SALT LAKE CITY.—The Western Silver Mines Company, operating in Mineral County, Nevada, has announced that plans have been completed for the construction of the first unit of its proposed 500-ton concentrating mill at its properties. The holdings of the company consist of ten claims and a mill site, aggregating 220 acres, the ore consisting of a highly siliceous vein material carrying values in gold, silver and lead. A. L. Jameson, of Los Angeles, Cal., is president.

SPRINGVILLE.—The Springville-Mapleton Sugar Company has commenced the construction of its new local sugar refinery.

OGDEN.—The Ogden Portland Cement Company, operating the plant at Baker, Utah, twenty-five miles north of this city, will manufacture potash, if the results of the experiments now being made prove satisfactory. This is the announcement made at the offices of the company, here. The experiments are being conducted at the plant by Manager H. C. Day and chemical experts have been brought here from California, probably from the Western Precipitation Co., of Los Angeles, who install the Cottrell process.

Virginia

NORFOLK.—The Linde Air Products Company, New York, is planning for the construction of a new local plant to cost about \$50,000.

NORFOLK.—The Vithumus Corporation is having plans prepared for the construction of a new plant for the manufacture of fertilizer at South Norfolk.

PORTSMOUTH.—The Portsmouth Cotton Oil Refining Corporation, which recently increased its capital from \$650,000 to \$1,000,000, has awarded a contract to Nichols & Linderman, Seaboard Bank Building, Norfolk, for the construction of a new two-story factory building, about 100 x 150 feet, to cost \$30,000.

STAR TANNERY.—The Mineral Ridge Manganese Corporation, recently incorporated with a capital of \$250,000, has commenced the development of its 700-acre tract recently acquired. At the present time the company has a daily capacity of 20 tons of manganese, which it is planning to increase to 60 tons. W. B. Shaffer, Nazareth, Pa., is president.

Washington

BELLINGHAM.—The Boundary Red Mountain Mining Company is planning for the immediate reconstruction of its power plant recently destroyed by fire. It is expected that the new plant will be ready for operation during the coming fall.

LOON LAKE.—The Loon Lake Copper Company is planning for a bond issue of \$40,000 to provide for the construction of a new mill, including flotation and grinding machines.

OROVILLE.—The Hudson Consolidated Mines Company has had plans prepared for the construction of a new 150-ton ball mill and flotation plant at its properties. Estimated cost of the structure is \$75,000.

SPOKANE.—The Rhodes Harvester Company has had plans prepared for the immediate construction of a new foundry addition, about 60 x 100 feet, to its plant, to cost about \$10,000. The company is also planning for extensive improvements to increase the present capacity.